AN OGDEN PUBLICATION DEVOTED TO GLASS TECHNOLOGY, ENGINEERING, MATERIALS AND GLASS FACTORY EQUIPMENT AND OPERATION

the glass industry

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Published by
OGDEN PUBLISHING COMPANY 55 WEST 42ND STREET, NEW YORK 36, N. Y.
JOHN T. OGDEN, Publisher
CYRIL B. DELGADO, Editor and Business Manager
KATHERINE A. HOWE, Production Editor
J. A. TEDESCO, Circulation Manager
Midwest Representative: Macintyre-Simpson & Woods
Chicago office: 75 East Wacker Drive
Cleveland office: 1900 Euclid Avenue

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The GLASS INDUSTRY, Vol. 35, No. 10, October, 1954. Published monthly by Ogden Publishing Company, 55 West 42nd Street, New York 36, N. Y. Subscription $4.00 a year, Canada and foreign, $5.00. Single copies 40 cents domestic, 60 cents Canada and foreign. Issues over three months old 60 cents; over one year $1.00. Entered as second class matter August 10, 1921, at the Post Office at New York, N. Y., under act of March 3, 1879.

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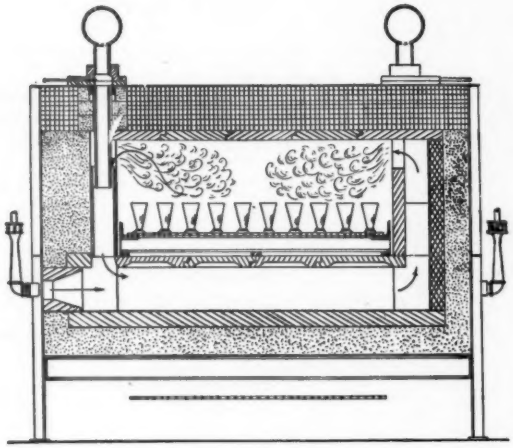

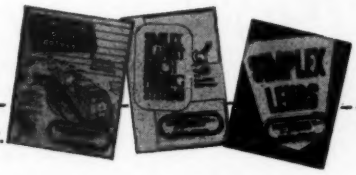

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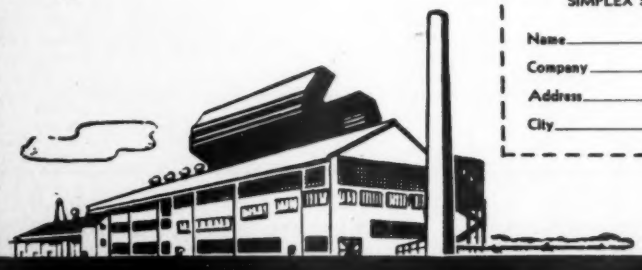

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THE GLASS INDUSTRY

VOLUME 35, NUMBER 10, OCTOBER, 1954

STATISTICAL QUALITY CONTROL IN GLASS MANUFACTURE

By A. P. STERGION, Manager Quality Control

Corning Glass Works, Corning, New York

Quality control, in a broad sense, is the prevention of defective manufacture regardless of what methods may be used for that prevention. If we can assume the interpretation, then quality control in the glass industry is as old as the industry itself. For years, measurements and inspections have been made on our materials, either on the finished product or at various process stages. From the information thus obtained, our machine operators were then able to determine what process adjustments should be made to prevent the manufacture of any defective material. Therefore, any company which is competing successfully in our industry today must have had some kind of a quality control program from the time it started its manufacturing operations.

However, a company, in order to continue competing successfully in the future must have a quality program that is different from what is implied above. In other words, it must have a "Statistical Quality Control Program". Such a program must not only employ the newest statistical techniques available, but also must make sure that the man in the shop has a workable understanding of such techniques, and at the same time have confidence in the new concepts of controlling quality.

In answering the question of how such a statistical quality control program can be introduced and applied to glass manufacture, I shall select a few illustrations from my experience at Corning Glass Works. I am happy to say that Corning Glass Works' interest in such a program has been and will continue to be very high because we realize that "Quality and Demand Go Hand-in-Hand". Our sales, and hence the security of our company and its employees, are dependent upon quality. "Corning Means Research in Glass" is a familiar slogan in the company's advertising. Our job is to see that another by-word, "Corning Means Quality in Glass", is an established fact. Our customers don't want just plain quality—they want the very best quality obtainable. It is for this reason that the aim of our program is not to hold quality down to some predetermined level, but to constantly improve it because the greater the degree of quality, the higher the demand for that product.

As we began the introduction and application of such a program into our plants, we immediately discovered that no one single method could be chosen as the right one to use in each plant. Reviewing other industries' problems, we also found out that even among quality control people there are differences of opinion as to how much a program should be introduced. As we progressed, we found out that the right way depended not only on the individual manufacturing organization, but also on its people, how they were affected, how they were approached, etc. No matter how carefully our system was devised and the technical details calculated, such a system would not have worked unless the people affected wanted it to work.

What I am trying to emphasize is that the success of our program depended on our being able to get the people involved to want it to work. In other words, we had a selling job to do, not to top management, but to line supervisors, to machine operators, etc. And how successful a selling job we did depended, in my opinion, on one thing only; that is, our approach. Looking back to the earlier days, I must admit that we ourselves have learned a lot since then about selling ideas and changes. I am happy to say that we now are well-accepted in all of our plants, which makes our work that much easier.

To be more specific, let us discuss some of the quality control techniques we introduced in order to more effectively control the quality of one of our main products, the incandescent lamp bulb. These bulbs are produced on the now famous Corning "ribbon" machine (Fig. 1) at speeds much too fast to be counted; that is, over 1,000 pieces per minute. They are produced by having a band

Presented before the 6th Annual Conference on Quality Control on September 11, 1954, at Rutgers University, New Brunswick, N. J.

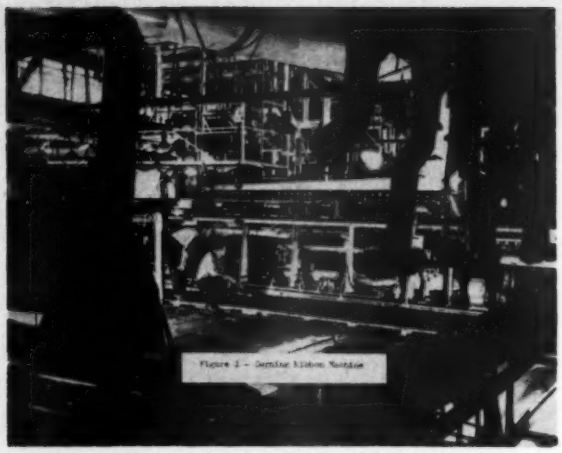

Fig. 1. Corning Ribbon Machine.

of molten glass flow from a continuous tank between rollers on an endless chain of orifice plates. Puffs of air push part of the glass down through holes. Almost simultaneously, molds come up to shape the bubbles into bulbs (Fig. 3) that will eventually encase the light-giving filaments. These bulbs are then transferred to a conveyor which carries them to the lehr (Fig. 2). From there, they go through a frosting unit and finally into hampers for shipment.

One of the first problems facing us was the control of visual defects, such as blisters, stones, mold rings, twisted bulbs, frost defects, etc. In the glass industry, such defects are quite important because not only do they influence our customer's reaction to the appearance of the article, but they also could affect their manufacturing efficiency as well as the ultimate performance of a finished lamp. We all know that the inspection of visual defects is quite a problem, mainly because it is very difficult to establish quality standards for such defects. In fact, it is even difficult to get people to talk realistically on the subject. Even if an agreement is reached, it is often next to impossible to record the decision accurately because of the infinite variety of sizes, shapes, locations, etc. Thus, the necessity for some judgment is inevitable. By testing inspectors and by keeping performance charts on their inspection results, however, we were able to eliminate as much of the variation existing between inspectors as was possible. Since this type of a problem exists in every industry, there is no need at this point to further expand on this.

Fig. 2. Lamp bulbs coming out of lehr or annealing oven.

Since our main objective at this stage of our program was to increase our assurance that a satisfactory product was being shipped to our customers, an intensive review was made of the existing sampling techniques used on this outgoing material. Following this review, more acceptable quality levels were established and, in many cases, our lot and sample sizes were changed so that they would give us the assurances required that the agreed upon quality levels were being met. Our methods of sampling were changed, and the hourly results obtained were plotted on "c" charts, thus showing the operators and foremen what their performance was from hour to hour. However, it was our feeling that this was an expensive way to control our product when you consider that (1) hampers had to be opened, repacked and resealed, (2) the ware had to be check-inspected considerably later after manufacture, thus not informing the operating group as soon as desired, (3) this procedure was a check on the so-called 100% production-inspectors instead of a check on the operating group and (4) this procedure required an additional inspector for process control.

In view of this, our next step was to use the available process inspector more effectively, and see if his activities could be combined with those of the check inspector, who was inspecting the packed product. To start this program, different "c" charts (Fig. 4) were introduced at the end of the "lehr" or annealing oven for use by the process inspector. Periodic samples of 50 were taken at random and the number of visual defects found were plotted as shown. As you notice, our visual defects are classified into three classes, i.e., critical, major and minor (Classes I, II and III, respectively). Rejection (red) and reinspection or holdout (green) lines were drawn vertically at various points (depending on the product and the average outgoing quality limits). The zone beyond the red line meant that ware exceeding this limit was too defective to have it 100% reinspected economically, and thus it was scrapped. The zone between the two vertical lines meant that the ware was unacceptable for shipment to our customers, but it could be 100% reinspected economically and satisfactorily. If at any time the number of defects found were on or within the holdout lines, we considered the ware satisfactory for shipment.

However, the above procedure was not put into effect until we were able to (1) correlate the results with those plotted by the check inspector, and (2) convince the production group that this was a more satisfactory way to control the visual quality of our ware. It was not difficult to show a correlation between the results of the two methods, but convincing the production group was another thing. We finally were able to do this by presenting and proving the following main advantages:

(1) Information was made available to the operators much sooner. By watching for trends and noticing the number and type of defects found, corrective

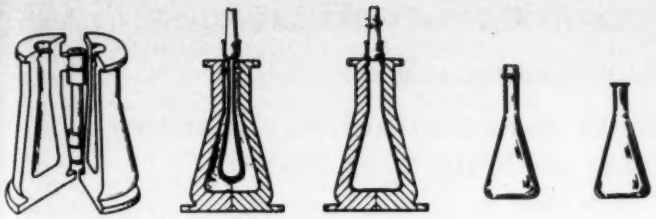

Fig. 3. Paste mold blowing.

action could often be taken prior to a rejection and thus result in less scrap, better quality, etc.

(2) More frequent samples could be taken since the time spent by the check inspector on the handling, opening and resealing of hampers could be spent on inspecting by the process inspector. As admitted by all, this was a very important factor because at the speeds of manufacturing, plus the desires of our customers for acceptable ware within very small lots of ware, more frequent samples were necessary.

(3) Reinspection costs were drastically reduced. This was possible by not packing the product if at any time a point on the control chart exceeded the rejection line, and by requiring the production department to inspect the ware while it still was on the conveyor belt if a point on the chart was between the holdout and rejection lines. Whenever this occurred, however, our quality control department re-checked the ware to see how effective the 100% inspection on the belt was. Since this one step eliminated a lot of handling by the reinspection department, which usually results in excessive breakage, our internal breakage losses were also reduced.

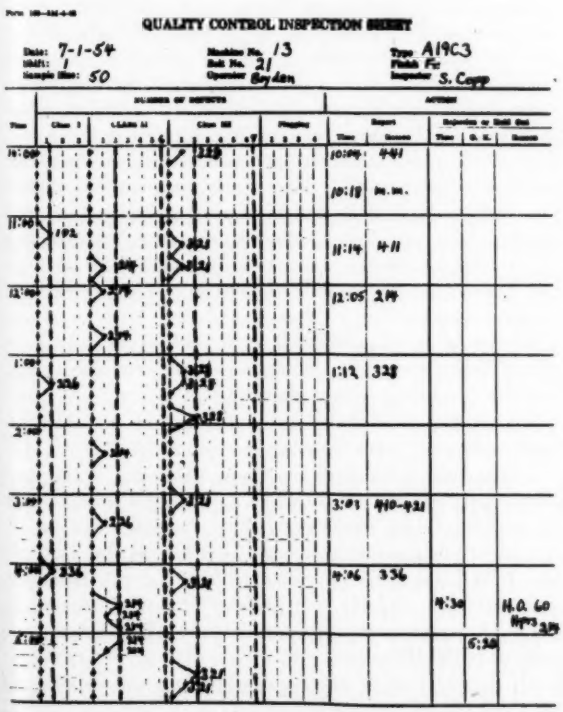

Fig. 4. Control chart for visual defects.

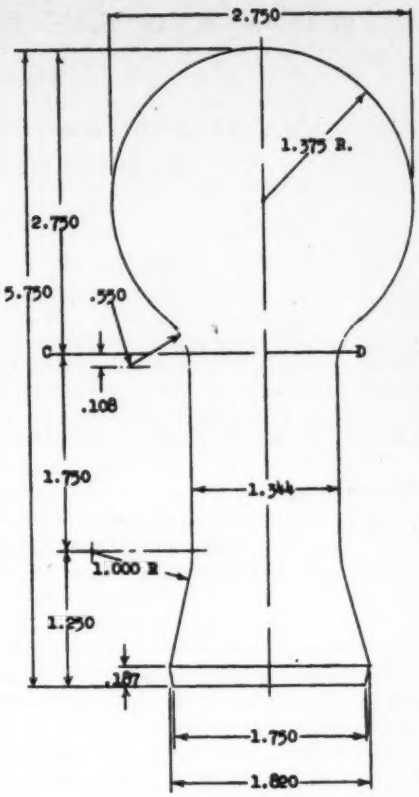

Fig. 5. Lamp bulb.

(4) At the same time, our quality control costs were reduced because, eventually, we were able to eliminate the need of a check inspector at each unit.

As time went on, the above procedure was being accepted more and more, thus making it possible for us to make additional modifications, where necessary, which would not have been accepted at the start of the program. Reducing the spread between the holdout and rejection limits was one of the changes made. Another one was to reevaluate our classification of defects and our average outgoing quality limits with the ultimate results of tighter and better quality standards. One of the main changes made, however, was to hold out ware for reinspection if two points in a row or two out of three points fell on or beyond the holdout limit, with the beginning of such holdouts going back to the first point. At the same time, we introduced the requirement of additional check samples to be made immediately if at any time the control chart hinted that a process shift had occurred. In this way, such check samples supplied to us more control information than an equal number of measurements taken periodically. This one change alone has considerably reduced our customer complaints and rejections because in this way we were able to control the quality of smaller lots of ware.

Even this is not enough. We are beginning to realize that shipping ware containing too high a percentage of borderline quality is not satisfactory. Although such ware may be within established and agreed upon visual standards, too high a percentage approaching such standards

(*Continued on page* 574)

STRAINS AND THE TRANSFORMATION REGION OF GLASS

By FRANCIS NAUDIN, Eng. D.

TRANSLATED FROM VERRES ET REFRACTAIRES, MAY-JUNE 1952

By KATE GAY EELLS* and NEILL M. BRANDT**

Parts I and II

Abstract

In Part I of the study, past investigations were reviewed. The original mechanical theory was cited and its limitations pointed out. The approach to the problem through the appearance and growth of structural gradient was described in detail. Advances in the knowledge of the structural state of glass were held to be necessary for real progress in the solution of the annealing problem. (NMB)

Introduction

The thermal strain which appears in glass in the course of the heating or cooling periods has formed the subject of numerous serious studies.

It has thus been easy to associate the origin of strain and its development with the appearance of a temperature gradient in a piece of glass. The permanent strain which exists when the glass is cold is related to that which originates at high temperature and which disappears because of plastic flow.

Besides these very important studies of mechanical strain in glass, there exists various works related to the variation of the physical constants of glass as a function of temperature. The investigators have demonstrated that all the physical constants, refractive index, density, resistivity, etc., undergo abrupt variations when the temperature reaches high values which constitute what has been called the transformation range of glass.

Only these last years have the investigators raised the following question: Has not the variation of the physical constants of glass the same cause as the appearance of internal strain? An experiment conceived by Madame Winter[1] showed that the regions critical for strain, as for the refractive index of glass, coincide exactly with the transformation range.

It seems probable that these two phenomena have numerous common points between them. The object of this work is to throw light on them.

Part I

The Problem of Internal Strain

General Remarks on Strain

Birefringence, a manifestation of glass subjected to the action of mechanical strain, is easily detectable and subject to precise measurement.

Glass under the action of an external force becomes doubly refractive. It acts in general like a uniaxial crystal whose optical axis has the same direction as the force, negative under compression. The difference in path between the extraordinary ray whose vibration is parallel to the direction of the force, and the ordinary ray whose vibration is perpendicular to the direction of the force, is proportional to this force and serves for its measurement. This ratio, called Brewster's constant, is a function of the composition of the glass.

In case of a force normal to the surface of the glass when n is the index of the unstressed glass, n_y the index in the direction of the force, n_z the index in the direction normal to the force, R the modulus of rigidity of the glass, C the speed of light, and p and q are parameters determined by the experiment, theoretical considerations make it possible to write[2]:

$$\frac{n_y - n_z}{n} = \frac{p}{2R}\left(\frac{q}{c} - \frac{p}{c}\right)$$

The path difference between the extraordinary ray and the ordinary ray per cm of glass traversed at the wavelength of the light used is expressed in millimicrons per centimeter (mμ/cm).

Let δ be the path difference in millimicrons, d the thickness of the glass in centimeters and P the pressure in bars. Brewster's ratio C is given in Brewster's by the formula:

$$\delta = CdP = (n_e - n_o)\ d$$

Where there are several forces, the birefringence is not proportional to the force at every point, but to the difference between the principal forces.

According to Balmforth and Holland[3], there is no or very little effect of time on Brewster's ratio. In fact, when the pressure causing 300 mμ/cm birefringence is released, the residual birefringence is of the order of the error in measurement. The Birefringence-Strain linear law is followed by all glasses (except perhaps silica and special glasses) as long as the resultant pressure, whether it be compression or extension, remains 100 bars or lower. The glass, therefore, approaches being a perfectly elastic substance.†

The value of Brewster's ratio for silica is 3.47. It is much higher for plastic substances such as celluloid [12], bakelite [50], and certain plastics.

Balmforth and Holland[3] give data on the variation of Brewster's ratio with the composition of the glass.

For glasses without soda or boron oxide but containing lead oxide, Brewster's ratio lies between 1.4 and 2. For glasses with boron oxide and soda but without lead oxide, the ratio is higher—between 2.8 and 4.4. If the lead oxide, PbO, content is increased to 75%, a null Brewster ratio (pockels glass) is reached; at 82% PbO, the ratio becomes negative. In compression the glass acts like a positive uniaxial crystal.

To date the effect of temperature and wavelength on Brewster's ratio has been unknown.

Under the effect of certain thermal treatment, glass be-

* Walton, New York.
** Mellon Institute, Pittsburgh, Pa.

† In a perfectly elastic body subject to deformation under a mechanical force, equal internal force develops opposite to the external force acting on the distorted body. Calling f the force per unit area, s the deformation per unit of length, the preceding law has the algebraic form: f = E.s in which the modulus of elasticity E is a constant dependent upon the nature of the elastic body.

comes doubly refractive. Since we can induce double refraction by subjecting the glass to an exterior force, we admit that the doubly refractive glass possesses strains. To calculate the value, we use Brewster's ratio after determining the birefringence which has arisen in the glass. More exactly, we measure a function of the difference in extraordinary and ordinary indexes ($n_e - n_o$).

Although the mechanical properties of glasses showing strain or birefringence are sometimes in demand in practice, for optical uses birefringence presents considerable inconvenience and the thermal treatment, annealing, has been introduced to remove it.

Authors have differed much in estimating the minimum birefringence tolerable for an annealed glass. Twyman[4] recommends 1/20 of the breaking force for present commercial glasses; Adams and Williamson[5] proposed values varying from 50 mμ/cm to 5 mμ/cm, according to the object sought; Morey[6] for optical glasses recommends 5 mμ/cm. Actually, this minimum value depends in the first place on Brewster's ratio. A force of 1 kg. acting on a cube with an edge of 1 cm produces a birefringence of 0.3 mμ/cm for a glass of medium Brewster ratio (3.3). Hence, we deduce that the 50 mμ/cm tolerance of Adams and Williamson[5] corresponds to a force of 167 kg/cm^2; that of Morey of 17 kg/cm^2, which, even in the second case, is considerable.

Formation of Strains

Let us recall, before outlining the development of strain in glass, certain standard definitions.

The reduction of birefringence or of strain necessitated studies of glass at various temperatures. The generation of permanent strain has been observed to be limited to a certain temperature region and below this region the glass cannot acquire permanent strain.* Morey[6] speaks of an annealing range whose upper limit is the temperature at which the strains do not exist because of the plasticity of the glass. The lower limit, called "strain point" by Littleton[7], is the temperature starting from which a piece of glass can be cooled as rapidly as possible without breakage, without entailing permanent strain. This temperature is always very poorly defined.

For a long time, strain (birefringence) and the temperature gradient existing in glass during cooling were assumed to be associated in a very simple way. Here is how the generation of strain was explained:

Let us take a strain-free glass plate sufficiently large for the edge effects to be disregarded at a quite low and very uniform temperature. Let us heat it on the two large surfaces. The outer layers immediately become hotter than the inner layers, therefore expand more than the inner layers. The cooler inner layers check the outer layers which have a tendency to expand over their entire surface. The outer layers, impeded in their expansion, are therefore found to be in compression and the inner layers in tension. For the glass considered as a whole, the strain changes direction progressively. Compression in the outer layers, tension in the inner layers, it, therefore, passes through a null value in the median region between the center and the exterior of the glass plate. When the temperature becomes uniform in the whole sample and remains lower than the annealing temperature defined above, the strain disappears with the decay of the temperature gradient. This strain is called *temporary strain.*

If now we undertake cooling of the sample, the core of the glass plate still remains hotter than the surfaces. Hence, a compression at the center and a tension in the surface which disappears when the temperature becomes uniform. The cooling is, under these conditions, an operation symmetrical to the heating.

Reciprocally, if there exists in a sample of glass without strain a temperature gradient, the disappearance of this gradient will be the cause of strain equivalent and opposite to that which should have been generated in the sample during the establishment of the temperature gradient. We shall therefore find, if the rate of temperature change has produced colder surfaces and a hotter core (gradient established by cooling), a compression on the surface and tension at the core. This strain, called *permanent strain*, disappears only after annealing.

In the previous experiments, and in the temperature range considered, the glass acted practically as an elastic solid. At sufficient high temperatures, the strain begins to diminish for the glass becomes more fluid. At higher temperatures, the strain disappears completely.

Let us cool, at constant rate, a slab of glass held at a temperature such that the internal strain in it has disappeared completely. A temperature gradient is generated in the mass of the glass and its distribution occurs according to an approximately parabolic law (Adams and Williamson[8], Morey[6]). At this temperature, the temperature gradient does not lead to any strain since the glass is fluid. The modulus of elasticity is very low and therefore cannot produce inner strain. If the temperature gradient is maintained by continuing the cooling to a quite low temperature, the disappearance of the temperature gradient produces permanent strain (compression at the surface, tension at the center).

In this way, Adams and Williamson[5] were the first to demonstrate that permanent strain appears at low temperatures and is equal and opposite to the strain which disappeared at the high temperatures.

Let us take the preceding strain-free sample at an intermediate temperature. Let us apply a cooling rate to it. In this temperature range, the internal strain which is created by the cooling rate (tension on the surface, compression at the core) relaxes only in part. Insufficient time is allowed by the cooling rate for the strain to decay completely because cooling started from an intermediate temperature where the strain relaxation rate has a finite value. When the cooling is achieved, the temperature gradient disappears and strain corresponding to the disappearance of the temperature gradient caused by cooling (compression on the surface, tension at the core) is generated. Now the strain which did not relax at the beginning of the cooling is opposite, and, hence, escapes becoming permanent when the temperature gradient disappears once the cooling is achieved.

The permanent strain is, therefore, less than in the preceding case. It can be zero only if there has been no relaxation at any time. A drop in temperature entails the appearance of permanent strain insofar as the strain created by the appearance or disappearance of this drop have been able to relax at a time in the thermal past of the sample. All this can be summed up in a few words:

The permanent strain of the glass is equal and oppo-

* Later we shall define the permanent strain of glass as opposed to temporary strains which disappear when the phenomenon causing it ceases.

site to that which relaxed at the high temperature in the course of the cooling.

This law has often been found at fault, but the explanation of the modern theory on the generation of strains in glass requires a brief statement concerning the transformation range.

Ideas Concerning the Transformation Region

Study of the physical constants of glass—refractive index, expansivity, resistivity—has shown the existence of two boundary states, one corresponding to low temperatures, the other to higher temperatures. Outside these boundary states, there exist states stable at high and low temperatures. The intermediate states between these two threshold temperatures are stable also. Experimental study has shown that the intermediate states and the state stable at high temperature, frozen at room temperature, are not stable. They tend spontaneously, although slowly, towards the state which for them corresponds to the stability at this temperature. This range, corresponding to the stable states intermediate between the stable state at high temperature and that stable at low temperature, is called the transformation range or region. A glass brought to a temperature in the transformation region tends towards a state of equilibrium corresponding to this temperature. Whatever the initial state of the glass may be, the final state will be the same, but will vary with the temperature.

The Idea of Structural Gradient

B. Daragan[9] did not find any induced birefringence in samples relaxed at temperatures 30C°, below their dilatometric transformation temperature and cooled in the open air. As the transformation range of the glass is located on both sides of the dilatometric transformation point, "any change of temperature starting from a temperature in this range causes a structural deviation from equilibrium which tends to be restored more or less quickly according to the temperature and the nature of the glass. This restoration is rarely attained completely (especially at the low temperatures), but the nearer we are to the state of equilibrium, the more homogeneous the cooled glass is structurally. So, starting from a structural state approximately at equilibrium at the temperature of relaxation, a hypothetically instantaneous cooling of the whole mass would produce no disturbance, and the glass, upon reaching ordinary temperature, would exhibit no birefringence." In practice the residual birefringence of a sample of glass, which arises on one hand from the structural gradient* and on the other hand from the thermal gradient, is always difficult to avoid completely in an annealing furnace.

The idea of structural gradient modifies our knowledge of the generation and development of strain in a sample of glass brought to a temperature in the transformation range. Let T_1 be this temperature. Let us suppose that the glass is composed of superimposed layers which are in equilibrium there. Let us then cool the glass rapidly to a temperature T_2 entirely outside the transformation region. This creates a nonequilibrium relative to temperature between the outer layer at temperature T_2 and the central layer at T_1. The intermediate layers will be at intermediate condition.

In the time that the state of nonequilibrium is modified, the central layer passes through the whole scale of the temperatures between T_1 and T_2, whereas for the intermediate layers this phenomenon is lessened.

Two cases are to be considered:

(1) Temperature T_1 within the transformation range and close to the lower limit. The rate of establishment of equilibrium at T_1 is low. Hence, during cooling from T_1 to T_2 the structural equilibrium cannot materially be attained for any of the temperatures in the interval T_1–T_2. There will be no or little structural change when the glass passes from T_1 to T_2, so little or no birefringence develops whatever the speed or rate of cooling may be.

(2) Temperature T_1 close to the upper limit of the transformation range. At this temperature, the rate of establishment of equilibrium is great, not to say instantaneous. During the time of transit from T_1 to T_2, there will be a state of nonequilibrium more accentuated as the cooling rate is lower, or rather if the cooling rate is of the same order as the rate of establishment of equilibrium. The resulting birefringence varies obviously in inverse ratio to the rate of cooling.

Now, let us suppose that at temperature T_1 the sample has not had time to get into structural equilibrium. Brought to the temperature T_2, it is found to be still farther from the state of equilibrium towards which it was tending at the temperature T_1. The rate of relaxation or, better, the rate of transformation increases and becomes great in relation to the rate of cooling (because of the breaking off of the equilibrium which was about to be established) so that the resulting birefringence again varies in the opposite direction to the rate of cooling.

From this reasoning it follows that the residue birefringence is a function of cooling rate and of the point of departure of the cooling process. It is necessary, in order to know the origin of a residual birefringence, to inquire into the thermal history of the sample of glass.

B. Daragan[9] has shown that the time during which samples, brought without strain from the high temperatures to a temperature in the transformation region, were left at this temperature had an influence on the permanent birefringence. He called this time of stabilization: time of potential relaxation.

In the case of samples without strain and without thermal gradient brought to stabilization temperature close to the lower limit of the transformation range and all cooled at the same rate, we ought to have found, according to Adams and Williamson[5], one same permanent birefringence. Now the permanent birefringence actually found was greater as the stabilization time was shorter.

Gillod[10] and B. Daragan[9] confirm these hypotheses by determining, each for a different glass, a temperature starting from which a glass completely in structural equilibrium can be cooled at any rate without introducing permanent strain.

It follows, then, that knowledge of the structural state of a glass is of prime importance to annealing. The structural theory, in opposition to the mechanical theory set forth by Adams and Williamson[5], maintains that strain is generated because of the difference in the specific vol-

* The term "structural gradient" was chosen by anology with the thermal gradient. When at a temperature T there is structural lack of equilibrium, the glass is in a structural state which corresponds to the state of equilibrium at the temperature T_s. Hence, a virtual difference $T - T_s$ of temperature and the term structural gradient to qualify the state of absence of equilibrium of the glass at this temperature T.

umes of the interior and of the surface of the glass. Knowledge of the structural state of a glass is deduced from measurements of density, or of refractive index. This latter measurement can be made with very great precision and is convenient for use when associated with a glass polishing workshop.

Lebedeff[11] showed experimentally that in a glass regularly heated, the irreversible birefringence appears when the temperature passes the lower limit of the transformation range. M. Gillod[10] confirms this fact by showing that the birefringence appears at the temperature where a decrease in the refractive index is found, starting from a glass stable at low temperature. Authors like Daragan[12] think that the birefringence does not represent the state of the glass or even its thermal gradient. Birefringence is caused by a difference between two indexes, and indicate nothing about the absolute value of each of them. For these authors, birefringence, a consequence of the anisotropy of the sample, is determined by the difference of the structural states of the core and of the surface. This in its turn entails a difference of specific volumes and, therefore, mechanical restraint. When tempered glass is brought to a temperature in the transformation range, its birefringence diminishes. Primarily this decrease is due to the effect of the temperature. There is shift toward equilibrium state in the structure of the glass.

It seems that in the transformation range there is a molecular rearrangement. The nearer we approach to the lower limit of the transformation range, the lower the rate of relaxation or of stabilization. However, at temperatures lower than those of the transformation range, this rearrangement may continue to exist. Thus tempered glass, being in an unstable state, tends with all rises in temperature to recover its equilibrium at the temperature where it is. Two forces are present: (a) restraint produced by the absence of equilibrium and (b) resistance to deformation. If the restraint is higher than the resistance, there is a molecular rearrangement with visible evidence of this rearrangement. On the contrary, if the resistance to deformation is higher than the restraint, the tempered glass keeps its pseudoequilibrium and is said to be stable.

According to Mueller[13], birefringence is the result of two different phenomena:

When the arrangement of the atoms is modified by an elastic deformation, the deformation produced by a [tensile] force generates negative birefringence which grows when the value of the refractive index increases. This force may also distort the atom and create an optical anisotropy which causes a positive birefringence. This phenomenon is directly connected with the chemical composition of glasses. In most glasses, the second effect is predominant, although glasses of high index display a negative birefringence. We might also be able to explain the variation in birefringence as a function of time by the progressive arrangement of the oxygen ions in the glass.

Importance of the Transformation Range in the Study of Strain

The mechanical or thermal gradient theory of the generation of strain has made considerable progress possible in the practice of annealing glass. However, its imperfections and limitations must be recognized and the structural gradient theory must be associated with it in order to explain the facts better. Some have thought that the structural gradient was a minor phenomenon, a sort of correction to the thermal gradient theory, which would never have broad application in annealing technique because of its very nature since annealing is general and not concerned with high precision.

It was the work of Mme. Winter[14] which showed the close relation which exists between the generation of mechanical strain and the temperature of the sample, a temperature related to temperature ranges characteristic of the type of glass.

Mme. Winter's experiment[14c] consisted in heating at fixed rate a sample of parallelopipedic shape (20 x 20 x 70 mm) and in measuring its birefringence by a four region penumbra analyzer*[15].

A temperature gradient was established at the start of heating, and the birefringence increased to a first maximum which corresponded to the maximum value of the temperature gradient. Then the temperature became uniform in the whole mass and the birefringence diminished to a constant value.

When the temperature reached the lower value of the transformation range, the birefringence again increased (rapidly this time) to a maximum and again diminished to zero as the temperature reached values near the upper limit of the transformation range. All during the heating, there existed a temperature gradient in the bulk of the glass: the outside was hotter than the core and therefore reached the transformation range sooner. Arrival in the transformation range brought sudden changes in the variations of the physical constants (in particular specific volumes). Since the complete mass of the glass did not attain the transformation range at the same time but the outer parts of the sample first, strain was generated. This strain decreased or relaxed in proportion as the core arrived at temperatures in the transformation range.

During early stages of cooling, there appears strain opposite to that described above. It is superimposed on the strain already existing and, consequently, the birefringence diminished. But when a regular cooling is established in the mass, the permanent strain increased progressively so as to tend towards the final value which it would have at room temperature, a value generally greater than the initial value at the beginning of heating. This increase was to be foreseen, since the glass was heated to a temperature higher than the annealing point of which glassmakers speak, but yet it must be noted that the appearance of the strain took place during heating and not during cooling.

Part II

Methods of Measurement

Abstract

Part II of the study dealt with the experimental technique employed. A detailed description of the optical instrumentation required for the separate or nearly simultaneous determination of refractive index and birefringence in a truncated prism within an annealing oven was given. A precision of $\Delta n = \pm 1.2 \times 1.0^{-5}$ *was attributed to the apparatus. The theory and manipulation of a penumbra analyzer for determining birefringence by measurement of the ellipticity of polarized light was also described. The ellipticity was im-*

* (This method will be described later.)

parted to plane polarized light by strain in the sample: ± 0.3 mμ/cm, (5%) precision was obtained.

Two types of study were made. In the dynamic type, the two properties were measured during various rates of heating. In the static system, the variation of the properties as a function at elevated temperature was the goal. NMB.

I. Measurements at Elevated Temperatures

A. Measurement of the Refractive Index. The method of measurement of the refractive index as a function of temperature was made in the following manner:

The sample was formed into the shape of an isosceles prism of an apex angle of about 35°. As indicated in Fig. 1, a cluster of parallel light rays was allowed to fall on the surface AB and AC of this prism. This cluster separated into two clusters of rays which travel symmetrically in the prism undergoing refraction at the surface where they enter, reflection from the opposite surface, refraction at the base and passage out into the air.

The measurement of the angle of exit of the two clusters 2i and knowledge of the angle of the prism 2a permits calculation of the refractive index n of the prism.

The formulas for the prism give the following relations:

$$\sin i = n \sin r_3 = n \cos (3A + r_1);$$

$$\cos a = n \sin r_1;$$

Eliminating r_1 and r_3, we get:

$$n = \frac{(\sin^2 i + 2 \sin i \cos 2a + \cos^2 a)^{1/2}}{\cos 3a}$$

and for the slight variations, dn, of the refractive index (with the temperature, for example) we get by differentiating:

$$dn = \frac{(\cos i \sin i + \cos i \sin 3a \cos a)\, di}{\cos 3a\, (\sin^2 i + 2 \sin i \cos 2a \sin 3a + \cos^2 a)^{1/2}}$$

We can always select the angle of the prism 2a so that at room temperature the exit angle of the two clusters will be null. Under such conditions, when heat is applied, angle 2i remains sufficiently small for the two emergent rays to be contained within the field of a lens, permitting measurements to be made by micrometer eyepiece without moving the lens. With i = 0 the preceding formulas are simplified and become:

$$n = \frac{1}{1 - 4 \sin^2 a} \qquad du = \tan 3a\, di$$

The precision of these measurements is easily calculated. If we operate with a goniometer lens whose caustic curve is 258.3 mm, 1 mm in the ocular plane represents 0° 13'19". When the micrometer has a cylinder of 100 divisions, one revolution of the cylinder causes the wire of the reticle to describe 1 mm in the focal plane of the lens. The position of the image of the slit of the collimator in the lens is easily determined to one division of the cylinder. This corresponds to an error in the index of a prism of borosilicate crown of angle 2a = 33° 56' equal to:

$$dn = 1.23212 \times 0.1937 \times 10^{-4} = 1.2 \times 10^{-5}.$$

It is therefore possible to estimate, when there is no air turbulence at entrance to or exit from the furnace, variations of refractive index of the order of one unit of the fifth place after the decimal. In our experiments we did not extend precision beyond five units of the fifth decimal for the refractive index.

B. Measurement of Birefringence. The measurement of the internal strain of a sample of glass in a furnace is always reduced to the measurement of the secondary birefringence; that is, to determination of the ellipticity of the light, previously linearly polarized, which traverses the glass.

The principal part of the apparatus used is a penumbra analyzer of four juxtaposed regions. We shall describe here only the principle of the instrument[15] (see Fig. 2).

The half-wave plate D and the Nicol prism A constitute an analyzer of ordinary penumbra. The quarter wave plate Q′ and the half-wave plate D have their neutral lines mounted parallel so that when an elliptical incident vibration, whose major axis is parallel to the neutral line OA common to D and Q, arrives at the analyzer, the photometric equality of the regions 1 and 2 is assured, but not that of the regions 3 and 4. On the other hand, if a rectilinear [plane polarized] vibration reaches the four-region analyzer, the quarter-wave Q′ transforms it to an elliptical vibration of OA axis. There can be photometric equality of the regions 1 and 2 only if the rectilinear vibration is parallel to OA.

To sum up, the quarter-wave Q transforms the elliptical vibration into rectilinear vibration after a rotation α which causes its neutral lines to be parallel to the axis of the elliptical incident vibration. Then, by a rotation β, the common neutral line OA of the Q′ quarter-wave and D half-wave plates becomes parallel to the rectilinear vibration transmitted by Q. Equality of the four regions is obtained only in this case.

The measurement of birefringence requires the following operations:

We turn the group Q, (Q′DA) till regions 3 and 4 become equal. Then we turn Q′DA with Q fixed so as to

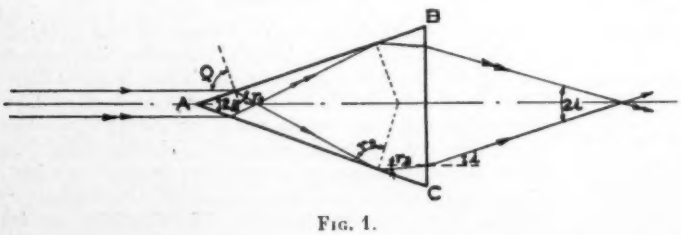

Fig. 1.

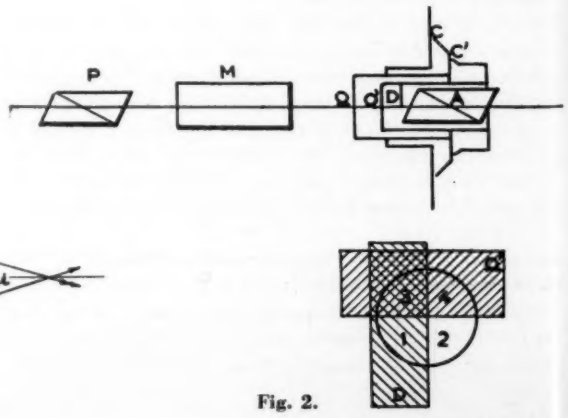

Fig. 2.

cause regions 1 and 2 to become equal; this also has the effect of diminishing the relative brightness of regions 3 and 4. We reestablish the equality of 3 and 4 and return again to make 1 and 2 equal. After some manipulations we reach equality of regions 1, 2, 3 and 4. The divided circle C corresponding to the rotation of group Q, (Q'DA) gives the α angles; circle C' corresponding to the rotation of (Q'DA) gives the β angles, whose tangent is the ellipticity of the incident light.

In a first operation we work without sample M; therefore with incident light polarized rectilinearly [plane polarized light]. The measurement made on C and C' indicate the zeroes of the graduations α and β. When the sample M is in place, we shall consider α and β starting from the "zero" found in the first operation.

The precision of the measurements is obviously a function of the precision with which the rotational position of the various elements is effected. It is not a function of the imperfections of the surface of the quarter-wave plate and is reduced, in the most favorable case, to the precision of determining the equality of brightness of the four quadrants of the field.

With the apparatus utilized, we could secure the measurements of $\frac{1}{4}$ division of the double graduated circle C'. let $dB = \pm \frac{1}{4}$. The retardation due to birefringence is expressed as a function of the path e of light through the sample and of the wavelength of the monochromatic light used:

$\lambda = 546.1$ m μ by:

$$e(n' - n'') = \frac{\beta\lambda}{100.}$$

The samples used all had a length $e = 4.5$ cm. For index variation per cm of glass traversed let

$$1 \text{ cm } (n' - n'') = \frac{546}{(100)\ (4.5)} = 1.21 \text{ m } \mu/\text{cm},$$

be the absolute error. In the case under consideration this was of the order of 0.3 m μ/cm and gave a limiting precision close to 5%.

C. Method of Simultaneous Measurement of Refractive Index and Birefringence. We attempted to combine these two set-ups in order to be able to obtain practically simultaneous measurement of the refractive index and of birefringence on the same sample[16]. The prismatic form of the sample was kept, but the apex was truncated. The plane surface thus formed, parallel to the base of the prism, provided a thick plate with parallel surfaces on which the measurements of birefringence could be made. In the majority of cases, we tried to measure the birefringence of a medium layer of concentrating the polarized light around the central plane of the sample. When we wished a greater validity of the birefringence, we used an outer layer close to the upper surface of the prism.

The set-up is represented in Fig. 3.

The two mirrors b and d, and the semi-transparent plate a, served only to permit use of a single light source. Portion abc, completed by eL, served only for index measurement. The set-up was: collimator, prism, micrometer lens, and triply bent light path. The portion adceA was the set-up for measurement of the birefringence in slightly convergent light. Each system was shut off, when its conjugate was operating, to prevent introducing a troublesome parasitic light.

The birefringence-refractive index measurements were made successively at intervals of about 30 seconds.

In order to preserve geometric form of the sample, the welded thermocouple was not placed in the interior of the glass but against one surface of the prism. The indicated temperature was that of the space very close to the sample. It could be slightly higher than that of the sample itself.

The temperature was measured by the aid of a copper-constantan thermocouple and registered by a Brown electronic potentiometer.

Progress of the Experiments

Two series of experiments were considered: first, the study with increasingly higher temperature peaks of the simultaneous variations of refractive index and of birefringence for different heating rates; second, the study of the variations of refractive index and of birefringence as a function of time at selected fixed temperatures.

The first study was called "dynamic study" and the second "static study".

Dynamic Study. We began by selecting, for each type of glass to be studied, a heating rate for which the strain, which was generated in the mass of the glass during heating, seemed to develop in a manner within the limitations imposed by the experimental technique. Once this heating operation was determined, the temperature of the furnace was raised from room temperature to some maximum value. Then the furnace was allowed to cool to room temperature. During the experiment, the refractive index and the birefringence were measured as often as possible.

Next we recommended heating at the same rate, but raised the temperature 10°C. above the previous maximum before starting cooling.

In about twenty operations the temperature peak reached a point where the glass became too mobile and the experiment was terminated for this kind of glass. In the same diagram we drew, as a function of the temperature, the variation of the refractive index and of the birefringence for the mercury line: $\lambda = 546.1$ m μ. The

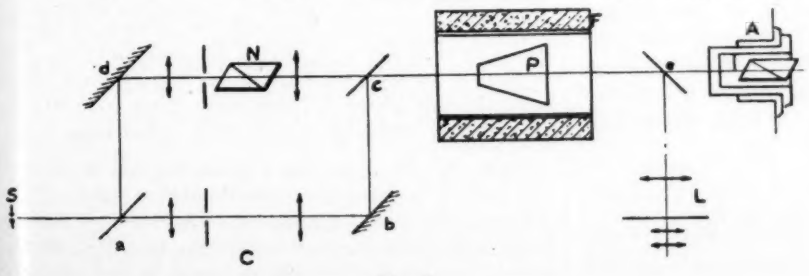

Fig. 3.

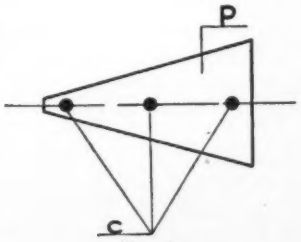

Fig. 4.

birefringence is expressed in optical retardation, i.e. in m μ/cm[17].

Static Study. At fixed temperatures, selected from the curves established by the dynamic study as being temperatures where the glass studied seemed to act in a characteristic manner, the variations of the refractive index and of the birefringence were measured as a function of time.

The curves, refractive index and birefringence at fixed temperature, drawn in the same diagram, make it possible to compare the evolution of these two physical constants as a function of time and to estimate the rates of establishment of equilibrium at different temperatures.

Four different types of French glasses were studied statistically and dynamically. The glasses were: a barium-crown (M2756), a borosilicate-crown (M2299), a light flint (M4900) and a dense flint (M3668). These optical glasses were, at least in the beginning, finely annealed.

D. Measurement of the Rate of Temperature Change in the Mass of a Glass. To study the rate of temperature change in the mass of the glass, we sank in the prismatic sample three thermocouples C, placed: one towards the base of the prism P, another in the center and the third towards the truncated apex (see Fig. 4). The temperature indicated by the different couples during a typical heating were then observed.

A curve was drawn of the temperature difference between two points in the bulk of the glass as a function of the temperature of the furnace atmosphere as it was defined by the thermocouple placed against the upper surface of the prism. From this curve it is possible to foresee the variations of the inner thermal gradient during heating. This curve appears to be the same for all the heatings used: rise from zero towards a maximum reached near 150°C. (this value depends on the heating operation), then drop towards a level at about 350°C., and then a slight rise till the end of the heating. The maximum difference in temperature between the truncated apex of the prism and its base never exceeded 35°C.

II. Measurement of the Room Temperature Refractive Index

The method of the annealed sample consists in holding a small sample of the glass at a given temperature for a given time, and rapidly cooling in order to freeze at room temperature the physical state present at the furnace temperature. At room temperature, the refractive index is measured by the most convenient method. The value found corresponds to the structural state attained by the glass at the high temperature and differs from the real value by the fact that this method does not take account of the purely thermal variation of the refractive index. This method was utilized by Lebedeff[17] who used glass parallelepipeds with edges 5 x 5 x 2 mm. We employed this method in order to determine the transformation range of each glass before undertaking the detailed study.

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(To Be Continued)

ANCHOR HOCKING ESTABLISHES NEW FLORIDA SUBSIDIARY

Wm. V. Fisher, President of Anchor Hocking Glass Corporation, has announced that its newly-organized, wholly-owned subsidiary, Tropical Glass & Box Company, a Florida corporation, has purchased the plant and property owned by Antonio Scalise which has been known as the Tropical Glass & Box Company.

Although Anchor Hocking owns and operates thirteen plants in the United States and Canada, there has been a long felt need for a Southern plant to round out its service. The addition of the Florida plant, therefore, will make it possible for the glass container firm to better serve packers and bottlers in the South.

A plant modernization program is being planned for the new subsidiary. When it is completed, it is anticipated that it will be able to accommodate all the glass container requirements of the firm's Southern customers. No immediate changes in personnel are contemplated, but Anchor Hocking engineers and other technicians will augment Tropical's present staff in order to more quickly integrate production and operations.

POLACOAT ADDS POLARIZED GLASS SHEETS TO PRODUCTION

The production of large sheets of polarized sheets has just been added to the facilities of Polacoat Incorporated. The development of special process equipment was made necessary by a call for several large rear projection daytime screens for installation in the conference and sales training rooms of an eastern concern. Such screens are illuminated by conventional picture projecting equipment from the rear side. The picture is clearly visible by the audience seated in front without need of turning off lights and drawing shades.

For durability, glass base material is used. A special stereo daytime screen is offered for projected 3-D. The present facilities produce screens to 70" x 80" sizes, which normally are made on ¼" plate glass. Sizes up to 30 x 36 are normally produced on 3/16 or ⅛" select glass.

• Owens-Corning Fiberglas Corporation has announced that it has completed its Kaylo distributor-contractor organization to serve 48 states, the District of Columbia and Alaska. The company said it has appointed 57 distributor-contractors of Kaylo industrial heat insulations.

OVERMYER HOLDS SIXTH IRON CLINIC

Opening the Sixth Annual Overmyer Iron Clinic, Lowell Roesner, President of Overmyer Mould Company, Inc., welcomed the close to 100 persons assembled to a day of discussion and social activity. This annual event has been growing in interest each year and again attracted a large group to discuss and review the progress made during the past 12 months in glass mold metallurgy.

The morning's activities included registration and a visit to Overmyer's Foundry Division. Following the tour through the foundry, the general discussions were held, including a discussion of developments in glass mold metallurgy, the proper care, repair and cleaning of mold equipment, and a discussion of the Lubracrome Process. The afternoon was devoted to social activities, and following luncheon, the golf tournament got underway. The evening cocktail hour at 6:00 P.M. set the mood for the Banquet at the Beeson Park Club House at which Max Hawkins, Sales Manager of the firm, presided. Mr. Hawkins gave a brief talk following the dinner and awarded the golf prizes.

In Mr. Roesner's opening remarks, he stated that this year's Clinic exceeded their expectations not only in attendance, but in actual participation in each phase of the program. He gave his thanks to the glass industry for making it possible through their cooperation and help for Overmyer Mould to develop and improve the equipment they produce.

The highlight of the Iron Clinic was the informal approach to the general discussions, a trend which has been growing throughout industry in recent years. As each speaker presented his particular phase of metallurgy, questions from the audience helped to enlarge the scope of the subject and pin-point the particular problems faced by the actual user of the equipment.

Opening the discussion program was Newton Davis, Overmyer metallurgist, who explained the workings of the cupola and the many controls necessary to produce all types of high quality mold irons that will react favorably under all conditions found in the high-speed production of glass. Each type of iron now being used by the industry was individually discussed and the alloy content explained to enable the group to understand the characteristics of each type of mold iron. Mr. Davis' discussion of the five Overmyer mold irons (THE GLASS INDUSTRY, January 1954) was something of a refresher for the assembled men. He said that while Overmyer has nothing new to offer as far as the foundry is concerned, their efforts this past year have been mainly to consolidate the things they have, make a few minor improvements and to make absolutely sure that every casting poured is of high quality. Their high standards require uniformity day to day and they feel they have achieved this goal as nearly as in possible metallurgically.

Mr. Davis said that in 1953, "we produced approximately 2,000 tons of castings for the glass industry." He went on to say that there are many types of melting units in use today for producing cast iron, but the most inexpensive and most efficienet is the cupola. He described the cupola as having simple construction around a cylindrical shell. It sets on legs, has several doors and is lined with a refractory brick. There is a wind box to admit wind and four uyeres to admit air into the cupola. Each morning the cupolas are readied, the doors are raised and a prop is put underneath them. They are then filled to a definite height with coke. This coke bed is measured carefully every day as this is an important phase of the operation. There is a constant air supply that introduces a continuous flow of air at all times to the cupola.

Here, Mr. Davis digressed to discuss the raw materials that go into the cupola to produce a good iron. The materials used consist of pig iron, steel, gates and risers, and machine shop scrap. It has been found through the years that some pig irons have inherent good qualities that carry through the melting process and improve the metal when it comes down through the spout. Overmyer uses three types of pig iron and, as a general rule, will blend two pig irons. Pig iron usually constitutes 42% of the metal charge and steel about 16%. In addition to the materials already mentioned, other materials that go into the charge are coke and a flux. In handling the coke for quality, it is watched for size, density and is kept under cover so that it will not be affected by weather conditions. For the flux, Overmyer uses dolomite limestone with cornel flux (a commercial flux).

Returning to the subject of production, Mr. Davis told how the coke is ignited after the proper coke quantity has been assured. It becomes red hot, the blast is turned on, the air is turned on and then the raw materials are

charged. As the raw materials start to melt down, the molten metal will appear. Five minutes later, the molten metal begins to drop down through the coke and in about 25 minutes, the first tap is made.

The introduction of the tapping phase of the process drew a question from the audience: "*What is the 'dope' that is used in the iron when the metal is tapped from the cupola and what is its purpose?*" Mr. Davis replied: "It is a mild graphitizer. It provides fluidity and with the use of it, we can control the chilling tendencies of the iron to such an extent that it stays away from hard edges and corners of the chilled surfaces. All of the iron is innoculated with this agent. The innoculation takes place as the molten stream of iron flows down the trough to the mixing ladle. It assures good fluid iron, free of hard edges and corners, and lessens machinability problems."

Following the first tap, a standard fracture test is made, studied to observe the structure and to make sure that the iron is in line for the castings that are going to be poured.

As Mr. Davis' discussion drew to a close, several questions were forthcoming from the audience: "*I have found that in some castings we purchase that have been alloyed with chromium, we get a layer of very hard iron that is very difficult to machine. How can this be avoided?*" Mr. Davis replied that if the chrome isn't mixed well into the solution in the iron when it is added, the result will be chrome segregation. It may not result in a complete layer, but there will be hard spots—or, at least, little shiny spots. We have found that the best combination to use is a 3 to 1 nickel-chrome ratio. With this amount, the nickel tends to offset the hardening effect of the chrome and you can still get the benefit of strengthening the matrix. Question: "*What can be done to prevent chrome segregation?*" Mr. Davis said that the iron should be good and hot before the chrome is added and if ferro chrome is used, some success is obtained by stirring the chrome in. If it is noticed that some chrome has floated to the top of the ladle, stirring will help, and if it gets worse than that, reladling the mixture several times might help.

As the questioning session came to a close, Wilmer Welch, Assistant Plant Superintendent of the Mould Division, took the floor and discussed the problem of maintaining molds in good condition. The first problem he took under consideration was that of repairing stripped threads in the neck of the mold. He said he believed that most of those in the audience probably did this by welding—drilling out much larger then tapping. He related that Heli-Coil Company (THE GLASS INDUSTRY, February 1954) produced a piece of equipment that looks something like a spring. With this you drill much larger and retap with a special tap. The Heli-Coil half-inch 13 tap is much larger than the standard half-inch 13 tap. The hole is tapped out in the back of the mold, ring, baffle or some such part, drilled and the Heli-Coil insert is placed in it. The Heli-Coil insert, Mr. Welch said, guarantees that the thread will outlast the original iron. The discussion of Heli-Coil drew a question from the audience: "*In using Heli-Coils in our shop, we found that they became loose and would back out of the mold. What is your explanation of this?*" Mr. Welch replied that Overmyer hadn't done too much with this. They have used it primarily in repairing jigs in the shop where the threads become stripped and used day in and day out. He said that they had not experienced anything of this kind, and went on to say that he thought this problem was created by drilling the first hole a little too large. The diameters of the holes vary depending on the kind of material being worked with, but the more the spring is compressed when inserting it, the tighter it is going to stay. He suggested decreasing the first drill size by as much as $\frac{1}{64}$" which would tend to tighten it up. In answer to the question, "*Does heating the piece affect the Heli-Coil?*", Mr. Welch replied that he didn't think it did.

Mr. Welch then took up the topic of mold cleaning. He thought it was readily agreed that vapor blasting and liquid honing is perhaps the best method that has been developed. In a little experiment he had made himself, he put a mold through a particular process, then cleaned one-half of the mold with liquid hone or vapor blast. The other half he let set for two days and then proceeded to clean it. The half he had cleaned immediately was in perfect condition, but the half he had allowed to go for two days was covered with rust specks and after cleaning it, there were pits all over the cavity. This would have to be re-machined before it could go back in production. This little experiment brought out the point that it is extremely important after a job has been taken off the machine that it be cleaned immediately. By not doing this, a perfectly good set of molds can be ruined, as well as creating doubt that the mold iron may be faulty.

Mr. Welch went on to say that another thing used at Overmyer occasionally is a No. 20 Colmonoy Rod. It has been found at Overmyer that it is best to use this rod on the joint, damaged corners and that type of thing in the cavity. It required little preheating of the mold and there are no hard spots adjacent to the No. 20 Colmonoyed applied rod. It is also easily machined, or worked off, and does not mark the ware in any way. The preheating on a large piece is about 200 to 300 degrees, Mr. Welch said.

The discussion of this rod brought the following question from a member of the audience: "*Does it take an expert welder to use #20 rod?*"; to which Mr. Welch replied: "You might do something similar to what we do here—we take a scrap piece, knock the corner off, work it down and practice a little bit. But, I honestly do not think it takes too long a time to become an expert at it since it isn't as complicated as normal welding; that is, it isn't as hard to get a good weld."

Vernon Ruble, Plant Superintendent of the Mold Division now took the floor to discuss the Lubracrome Process, and the results achieved thus far in its practical application in several glass plants. Earl Flatter, Vice President of Overmyer, was to have been the speaker on this topic, but when he was called out of town, Mr. Ruble was requested to handle the subject.

Although there are still some "bugs" to be worked out in this process, some firms have been using it for about two years—some in this country for one year—and a lot of good results have been obtained. The Lubracrome Process, Mr. Ruble explained, is an entirely different process than chrome plating, and it is practically guaranted not to chip or peel. In Rockwell hardness, it is quite a good deal harder and has a chorme-to-metal bond. He said it was his understanding that with the Lubracrome Process the structural stress and strain on the base

(*Continued on page* 578)

PROPERTIES OF SELECTED OPTICAL GLASSES

The National Bureau of Standards has recently completed a coordinated study of the physical properties of five selected optical glasses, obtaining comparative data on refractive indices, spectral transmissive properties, densities and thermal expansivities for each of the materials studied. The resulting charts and tables are expected to be of considerable utility in optical glass technology and research because they provide so great a variety of data on each specific glass. Ordinarily these properties are not all measured on the same glass. In view of the recent interest in image forming systems utilizing infrared radiations, the measurements of index of refraction and transmittance have been extended considerably beyond the spectral range for which optical glass is generally catalogued.

The five groups of samples (Table 1) were each selected from a typical melt of the types of optical glass produced and annealed in the Bureau's experimental glass plant. Indices of refraction were measured over the entire spectral range for which the glasses can be used in the construction of optical components, and the indices were represented by a dispersion equation.

TABLE 1

Refractive indices and transmittances of the five selected optical glasses studied by the National Bureau of Standards.

Glass	Index of Refraction	Transmittance
A	1.517	64.5
B	1.573	5.74
C	1.621	36.2
D	1.649	33.8
E	1.673	56.2

Four spectrophotometers were utilized in measuring spectral and internal transmittance for the range 200 to 1000 millimicrons. Densities were determined by the method of hydrostatic weighings with distilled water as the immersing liquid. Coefficients of linear thermal expansion were measured by a strain gage method during three cycles of heating and cooling through the range from room temperature to 60°C.

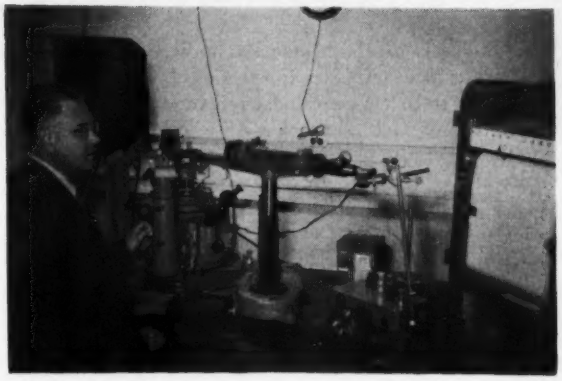


Fig. 1. The National Bureau of Standards study of optical glasses included refractive index measurements far into the infrared. Here an infrared spectrometer is being used to determine the index of refraction of a specimen of optical glass mounted on the rotating table at left.

The data collected in the Bureau's investigation have been published in four papers appearing in the June 1954 issue of the *Journal of Research of the National Bureau of Standards* under the following titles: Refractive indices of five selected optical glasses, by R. E. Stephens and W. S. Rodney. Spectral transmissive properties of five selected optical glasses, by H. J. Keegan, Marion A. Balknap, and Dorothy J. Cordrey. Densities of five selected optical glasses, by Charles T. Collett. Thermal expansions of five selected optical glasses, by Peter Hidnert.

OLIN MATHIESON ELECTIONS

The election of the following officers of Olin Mathieson Chemical Corporation, formed August 31 by the merger of Olin Industries, Inc. and Mathieson Chemical Corporation, has been announced by John M. Olin, Chairman of the Board, and Thomas S. Nichols, President.

Named as Chairman of the Finance Committee and Vice President for Finance was John W. Hanes; F. Stillman Elfred, John C. Leppart, Stanley de J. Osborne were named Executive Vice Presidents.

Those officers also elected were: Russell R. Casteel, Vice President; Norman H. Collisson, Vice President for Operations; Donald W. Dummond, Vice President for Operations; R. L. Hockley, Vice President for Operations; Russell Hopkinson, Vice President for Development; Robert W. Lea, Vice President for Organization; R. B. Lewis, Vice President for Financial Analysis; David T. Marvel, Vice President for Sales; Milton F. Meissner, Vice President for Operations; S. L. Nevins, Vice President for Operations; Walter F. O'Connell, Vice President and assistant to the Vice President for Finance; Fred Olsen, Vice President for Research; Ralph A. Ostberg, Vice President for Production; J. J. Tooly, Vice President for Operations; Theodore Weicker, Jr., Vice President for Overseas Operations; Edgar W. Taft, Treasurer; C. C. Tallman, Comptroller; Gordon Grand, Jr., Secretary; E. R. Van Vliet, Assistant Treasurer; A. P. Winsor, Assistant Secretary.

ARMOUR SENDS REFRACTORY SPECIALISTS TO PAKISTAN

A refractory specialist is being sent to Pakistan by Armour Research Foundation of Illinois Institute of Technology to assist in the production of refractory brick at a manufacturing plant in Malakwal. He is Harry T. Bellamy, who developed one of the earliest refractory insulating bricks to be used in direct contact with the source of heat.

Mr. Bellamy will serve as refractory technologist to the North Western Railway of Pakistan, which owns the plant. His assignment will be to aid in phase two of a Foundation project to advise in the building and operation of the plant under the Foreign Operations Administration's foreign aid program. Phase one, recently completed, consisted of design and erection of the plant and determination of suitable local raw materials.

GLASS CONTAINERS, INC. USES SPECTROPHOTOMETER FOR COLOR UNIFORMITY

Color checks on both colorless and amber glass containers are made at Glass Containers, Inc., Los Angeles, California, so that a permanent record is available of the exact color of each batch of glass when customers question the adherence to color specifications. Color measurements are also needed to control the appearance of the finished product when it becomes necessary to use raw materials from different sources and when quantity of decolorizing agents are varied.

By means of transmission measurements made with the Beckman Model B Spectrophotometer at a series of preselected wavelengths, data were obtained for a color transmission curve and for tristimulus color values. With this curve and the tristimulus values, it is an easy matter to check on color uniformity from one batch to another, and to obtain valuable clues as to the reasons for any color deviations which may occur.

The spectral curve provides the basic physical data—the transmission characteristics of the glass sample as a function of wavelength in the visible range. The tristimulus values derivable from the curve specify precisely the correspondent color sensation when the glass is viewed by a "standard" observer in the light of a standard illuminant. The three tristimulus values represent the amount of light of three standard prevailing colors which would yield the same color sensation if mixed additively. Each of the tristimulus values is obtained by weighing the contribution of various spectral positions of the transmitted light by their respective function, defining primary color content of these spectral regions, then totaling the contributions.

It should be observed that while two samples having identical transmission curves invariably show the same color when viewed in the same light by the standard observer, and are represented by similar tristimulus values, the converse may not be true; i.e., samples of identical tristimulus specifications (samples which appear the same under a given illumination) may or may not have identical spectral transmission characteristics.

Tristimulus values allow the specification of color in terms of three characteristics convenient for purposes of color comparison and matching: (1) Dominant wavelength—a measure of hue. (2) Color purity—a measure of saturation. (3) Visual brightness—a measure of brightness.

The dominant wavelength of flint glass, for example, can vary from 560 and 590 millimicrons, indicating that its hue ranges from green through yellow. The use of a single number identifies hue positively and precisely.

Purity is a measure of the saturation of the dominant wavelength with respect to the illuminant, which for the purpose of these measurements is average daylight (Illuminant C). For example, if the dominant wavelength is 575 millimicrons and the purity is 1.7 per cent, it can be stated that 98.3 per cent of the response is due to Illuminant C and 1.7 per cent is due to spectral light of the dominant wavelength. As the glass approaches neutrality, less response is due to spectral light of the dominant wavelength and thus purity will decrease.

Brightness or visual efficiency is a measure of trans

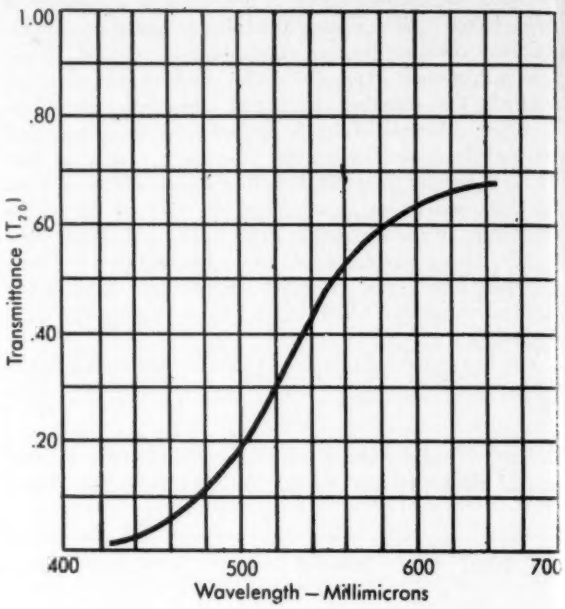


Figure 1. Typical Spectral Curve for Amber Bottle Glass

mission efficiency and is independent of dominant wavelength and purity. For example, if a glass is high in iron and requires a large percentage of decolorizer for minimum purity, the brightness will be low since the transmission efficiency has been decreased.

Procedure: The ten selected ordinate methods, (as described in *Handbook of Colorimetry* by A. C. Hardy, is used to obtain tristimulus values. A curve of per cent transmittance vs. wavelength is also made from this data. An empty sample holder is used as a blank for these measurements. A data sheet for obtaining and calculating tristimulus values is shown in Fig. 2. The handwritten numbers represent data used as an example while other figures represent multiplying factors and the wavelengths at which data are taken.

A special bottle is cast, having a thick bottom. The bottom is cut free, lapped and polished. Sample thickness is 10 millimeters for flint glass and 2 millimeters for amber glass. Care must be taken in choosing samples for measurement since imperfections cause errors. In a 1½- inch sample, for example, stria may cause up to 10 per cent error. The sample thickness is carefully measured and recorded. Standard sample thickness for amber glass is 2.000 mm.

Readings are taken for T_t (transmittance at actual thickness) at the ten wavelengths indicated in Fig. 2 for X, Y and Z respectively. To calculate tristimulus values, convert T_t to $T_{2.0}$ (transmittance at 2.000 mm sample thickness) by means of the following equation or by a nomograph obtained from this equation:

$$\log_{10} T_{2.0} = \frac{\log_{10} T_t}{l_t}$$

$T_{2.0}$ = Transmittance at 2.000 mm

T_t = Transmittance at sample thickness

l_t = Sample thickness

In a similar manner, corrections can be made for flint glass sample thickness variation from the standard 10.000 mm thickness. Next add the ten values under column heading $T_{2.0}$ for (X), (Y) and (Z), then multiply each of these sums by the corresponding multiplying factor shown on the work sheet to obtain the tristimulus values X, Y and Z. Obtain the trichromatic coefficients x, y and z by dividing each of the tristimulus values by the sum (X + Y + Z). The visual efficiency or the relative brightness is given directly by the value of x and y on a suitable chromaticity diagram found in Hardy's *Handbook of Colorimetry*. Draw a straight line from the Illuminant C point through the plotted point and read the dominant wavelength at the intersection of the extension of this line and the spectrum locus. The purity may be interpolated from the chart by means of the contour lines of purity.

A transmission curve is plotted from the data corrected for thickness recorded on the data sheet. An example of a transmission curve for amber bottle glass corrected for standard sample thickness of 2.000 mm is shown in Fig. 1.

This method for color determination of glass can also be used for other transparent or translucent materials, such as plastics and liquids, including wines and other beverages, vinegar, syrups, perfumes, pharmaceuticals, lacquers and varnishes.

The use of ten selected ordinates illustrated here is satisfactory for tints, but deeper colors may require the greater accuracy of a 30 or even a 100 ordinate system. Tables of data for these two systems are give in Hardy's *Handbook of Colorimetry*.

REFERENCES

Hardy, C. A., *Handbook of Colorimetry*, Technology Press, Cambridge, Massachusetts, 1936.

Judd, Dean B., *Color in Business, Science and Industry*, John W. Wiley and Sons, Inc., New York, 1952.

TYPICAL DATA SHEET FOR GLASS COLOR MEASUREMENTS

TEN SELECTED ORDINATES ILLUMINANT "C"

SAMPLE THICKNESS: *1.5 mm Amber*

(X)			(Y)			(Z)		
mμ	T_t	$T_{2.0}$	mμ	T_t	$T_{2.0}$	mμ	T_t	$T_{2.0}$
435	.050	.019	489	.215	.130	422	.035	.012
461	.120	.060	515	.365	.266	432	.040	.015
544	.525	.440	530	.460	.365	439	.045	.017
564	.620	.550	541	.520	.435	444	.060	.024
577	.655	.588	552	.565	.477	450	.075	.032
589	.680	.614	562	.605	.525	456	.085	.037
600	.700	.637	573	.645	.575	462	.105	.050
611	.710	.649	585	.675	.607	469	.130	.066
624	.725	.669	601	.710	.649	478	.165	.092
646	.730	.675	627	.725	.670	495	.255	.164

$\Sigma X_{T_{2.0}}$ 4.901 $\Sigma Y_{T_{2.0}}$ 4.699 $\Sigma Z_{T_{2.0}}$ 0.509

$X = 0.09806 \left(\Sigma X_{T_{2.0}}\right) =$ .48059

$Y = 0.10000 \left(\Sigma Y_{T_{2.0}}\right) =$ .4699

$Z = 0.11814 \left(\Sigma Z_{T_{2.0}}\right) =$ .06013

TOTAL = 1.01062

DOMINANT WAVELENGTH = 579.1 mμ

PURITY..... = 84 %

VISUAL EFFICIENCY..... = 46.99 %

TRICHROMATIC COEFFICIENTS:

x = .4755

y = .4650

z = .0595

Figure 2

NUMERICAL DATA FOR THE CALCULATION OF THE THEORETICAL HEAT INPUT FOR THE FUSION OF GLASS

The Second of a Series of

INFORMATION CIRCULARS OF THE INSTITUTE OF SILICATE RESEARCH

Part I

Admittedly, our present glass furnaces are rather unsatisfactory as to their thermal efficiency. They are machines for chemical reactions, with a tremendous waste of valuable heat energy. The expense for fuel could be much reduced if these wastes could be reduced. The fact that our present regenerative or recuperative furnaces are highly uneconomical may be borne with a certain fatalism, but the scientist who is studying the theory of glass melting must protest against the present waste.

In practice, the so-called heat-balance (Sankey) diagrams are used for illustrating the heat inputs and outputs; that is, the heat "flow" through the furnace. Several ingenious papers have also been written with such diagrams for the conventional glass furnace*. The Sankey diagrams give full information on the heat inflow (by the combustion of the fuel and the backflow of "regenerated" heat energy from the checkerwork of the regenerator), and the outflow (most of which is a real "loss" by radiation from the hot walls of the furnace and from all the warm parts of the apparatus, and chiefly through the stack). Two really modern Sankey diagrams for glass melting furnaces, given by I. Peychès,** may be men-

* Among the classics of this field, we mention H. Maurach's monograph "Der Wärmefluss in einer Schmelzofenanlage für Tafelglas," München, Oldenburg Publ. 1923. For an excellent illustration of the distribution of the heat losses in the different parts of a pot furnace, see H. Maurach, Zs. Ver. deutsch. Ingen. *68*. 1924. 520-524, and the article in Dralle and Keppeler's handbook "Die Glasfabrikation", 2nd edition, Vol. I. 1925., especially pp. 380-389. For American readers, the articles of A. E. Badger, V. C. Fugman and H. I. Vormelker, GLASS IND. *16*. January 1935. pp. 5-10, and of R. D. Pike and G. H. West, J. Am. Ceram. Soc. *11*. 1928. 734-744, or the papers of W. Friedmann, J. Soc. Glass Technol. *14*. 1930. 91-102; *20*. 1936. 596-639, will be more easily accessible.

** Bull. Inst. du Verre. *1*. Sept. 1946. No. 4. 1-15; an English translation was made by F. W. Preston, GLASS IND. *28*. 1947. pp. 173-177; 238-242. Compare also the data given in the "HANDBOOK OF GLASS MANUFACTURE", by F. V. Tooley, Ogden Publishing Co. 1953. pp. 139-148, with Badger's diagram on p. 143, and S. R. Scholes' monograph "Glass Tank Furnaces", Ogden Publishing Co. 1941.

TABLE I.

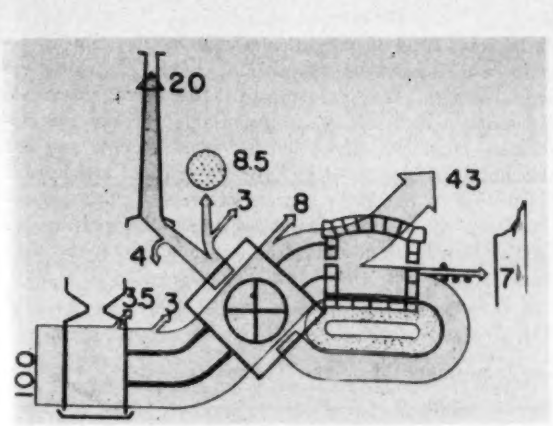
Increments and Coefficients a and c_o for the Computation of Specific Heats of Glasses

	Oxide Increments		Coefficients	
	Winkelmann and Schott	Sharp and Ginther	a	c_o
SiO_2	0.1913	0.1887	0.000468	0.1657
Al_2O_3	0.2074	0.1963	0.000453	0.1765
B_2O_3	0.2272	0.2329	0.000635	0.198
Na_2O	0.2674	0.2736	0.000829	0.2229
K_2O	0.1860	0.2059	0.000335	0.2019
Li_2O	0.5497	not detd.	not detd.	not detd.
CaO	0.1903	0.1871	0.000410	0.1709
MgO	0.2439	0.2346	0.000514	0.2142
ZnO	0.1248	not detd.	not detd.	not detd.
BaO	0.0673	not detd.	not detd.	not detd.
P_2O_5	0.1902	not detd.	not detd.	not detd.
SO_3			0.000830	0.198

TABLE II.

Thermochemical Data of the Most Important Dissociation Reactions

Batch Raw Material	Reaction Equation	ΔH_{25} Cal/Mole	Cal/kg
Boric Acid	$2\,[B(OH)_3] \rightarrow [B_2O_3] + 3H_2O$ vapor	24,210	381.5
Borax	$[Na_2B_4O_7.10H_2O] \rightarrow [Na_2B_4O_7] + 10H_2O$ vapor	141,500	371.5
Soda	$[Na_2CO_3.H_2O] \rightarrow [Na_2CO_3] + H_2O$ vapor	13,800	111.3
Potash	$[K_2CO_3.1.5H_2O] \rightarrow [K_2CO_3] + 1.5H_2O$ vapor	22,780	137.8
Kaolinite	$[Al_2O_3.2SiO_2.2H_2O] \rightarrow [Al_2O_3.2SiO_2] + 2H_2O$ vapor	55,820	216.0
Alumina Hydrate	$2\,[Al(OH)_3] \rightarrow [Al_2O_3] + 3H_2O$ vapor	11,190	142.2
Dolomite	$[CaMg(CO_3)_2] \rightarrow [MgCO_3] + [CaCO_3]$	— 1,600	— 8.68
Na_2Ca-Carbonate	$[Na_2Ca(CO_3)_2] \rightarrow [Na_2CO_3] + [CaCO_3]$	— 2,070	— 10.04
K-Ca-Carbonate	$[K_2Ca(CO_3)_2] \rightarrow [K_2CO_3] + [CaCO_3]$	— 720	— 3.02
Calcite	$[CaCO_3] \rightarrow [CaO] + CO_2$ (1 atm. pressure at 900°C.)	+ 42,570	+ 424.6
Magnesite	$[MgCO_3] \rightarrow [MgO] + CO_2$ (1 atm. pressure at about 600°C.)	+ 28,650	+ 340.0
Witherite	$[BaCO_3] \rightarrow [BaO] + CO_2$ (1 atm. pressure at 1,360°C.)	+ 61,000	+ 309.0
Na-Niter	$2\,[NaNO_3] \rightarrow 2\,[NaNO_2] + O_2$ (1 atm. pressure at 350°C.)	+ 25,100	+ 295.5
K-Niter	$2\,[KNO_3] \rightarrow 2\,[KNO_2] + O_2$ (1 atm. pressure at about 500°C.)	+ 27,880	+ 275.8
Pyrolusite	$2\,[MnO_2] \rightarrow [Mn_2O_3] + \frac{1}{2}\,O_2$ (1 atm. pressure at 500°C.)	+ 6,800	+ 77.2
Mn_2O_3	$3\,[Mn_2O_3] \rightarrow 2\,[Mn_3O_4] + \frac{1}{2}\,O_2$ (1 atm. pressure at about 960°C.)	+ 8,250	+ 52.2
Minium	$2\,[Pb_3O_4] \rightarrow 6\,[PbO] + O_2$ (1 atm. pressure at 580°C.)	+ 16,320	+ 23.9



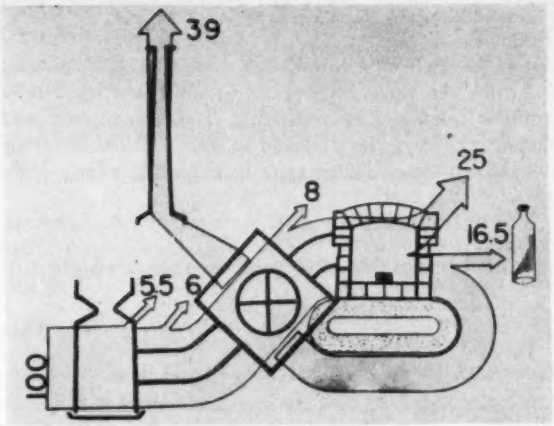


Fig. 1 and Fig. 2. Sanky diagrams of two typically different glass tank furnaces.

tioned here, namely one for a bottle glass tank, and one for a drawn sheet glass tank furnace. Figs. 1 and 2 give these diagrams. Although highly simplified here, they show a very significant difference between the thermal characteristics of bottle and sheet glass operations. The nature of the glass product markedly affects the heat output character of the furnaces.

This fact makes it evident that the practical heat balance as expressed in the Sankey diagrams cannot illustrate the thermochemical efficiency of a given furnace. This factor, as a relative numerical datum, depends on the theoretical heat input which is required by the multiple chemical reactions in the glass melting process. The theoretical heat requirements must, therefore, be derived as accurately as possible from thermochemical calculations. In principle, the same basic problems arise which are familiar to the metallurgist in reducing the metal in a given ore from the charge of the blast furnace, or to the Portland cement manufacturer in burning a raw mix to the clinker. The reactions in glass batches, however, are far more complex, and data for their calculations are rather scarce and widely scattered in the literature.

To help the glass chemist in these problems, Carl Kröger* has published a very useful article approximating the solution as well as is possible with available data. This author discusses two ways of attack, comparing them to previous calculations of the theoretical heat requirements for Portland cement burning**:

(1) The increases in heat content of the raw materials are determined from room temperature up to the fusion temperature. To the resulting heat quantity are added the heats of reactions in the raw mix (batch) at the temperatures of the single reactions, plus the increases in the heat content of the material in its final fused state. This is the ordinary way of calculating, but another equivalent method is the following.

(2) The reactions in the batches are imagined to take place at room temperature. To the resulting heat amount are added the increases in the heat content, which are required for bringing the reaction products to the temperature of the fused material.

For both ways, the necessary thermal data available are not sufficiently consistent, nor of adequate degrees of reliability. Best known are the *specific heats*, which for the gaseous products of the reactions (especially H_2O,SO_2,CO_2,O_2,NO) are easily found in standard works.† Until recently, the specific heats of the resulting glasses have been much more problematic. The classic approximations by the additivity formula of Winkelmann and Schott are not satisfactory. They have been fundamentally reviewed by D. E. Sharp and L. B. Ginther††. For the calculation of the (average) specific heats of the glasses up to 1300°C., these authors have given the

* Glastechn. Ber. *26*. 1953. No. 7. 202-214.

** See e.g. W. Eitel, B. Goslich, and A. Müller, Rock Prod. 1932. March 12; H. Zur Strassen, Zement *30*. 1941. 231-234, 250-252; W. Anselm, Radex-Rundschau 1950. 3-61.

† Landolt-Börnstein's "Physikalisch-Chemische Tabellen". 5th edition. Berlin. 1923-1927; s.a. the excellent tables given by E. Justi in D'Ans and Lax, "Taschenbuch für Chemiker und Physiker". Berlin 1943. pp. 1054-1061.

†† J. Amer. Ceram. Soc. *34*, 1951. 260-271.

Heat Losses, in per cents of the total heat input

Part of the system from which heat is lost	Bottle Glass Tank	Sheet Glass Tank	
Producer Body, Ash, Water	5.5	3.5	
Producer Gas Flue to Valve, Soot	6	3	
Gas and Air Valves, Water Seals	8	8	
Waste-Heat Boiler		8.5	
Both Sides of Regenerators	39	3 and 4	35.5
Waste Gas Flow to Stack		20	
Furnace Crown and Walls	25	43	
Sensible Heat of Produced Glass	16.5	7	
Thermal Efficiency = Sensible Heat of Glass / Same + Furnace Crown and Wall Losses	$\frac{16.5}{16.5+25} = 40\%$	$\frac{7}{7+43} = 14\%$	

formula $\bar{c}_p \Big|_{o^\circ}^{t^\circ} = \frac{a\,t + c_o}{0.00146\,t + 1}$, (t in Celsius degrees)

in which the coefficients a and c_o for the single oxides are also calculated by additivity. The "increments" and these coefficients are tabulated in Table I. The accuracy with which the calculation can be done is relatively high, namely 1 per cent.

The thermochemist's arsenal for the calculation of heats of reactions in general chemistry is large, but in the special field of the silicates, many uncertainties remain which must be taken into account in using the available data. It is unfortunate that a thorough critical discussion which is so indispensable for the thermochemist cannot be given in this short excerpt and has also not been attempted in Kröger's original article. An illustration of the many sources of errors in the thermochemistry of the silicates, however, was given by W. Eitel†. It will be advisable to understand that the data

(*Continued on page* 580)

† "Thermochemical Methods in Silicate Investigation". Rutgers University Press. 1952.

TABLE III.

Thermochemical Data of the Reactions of the Most Important Binary and Ternary Silicates

Reaction Equations	Temperature Range in °C.	Δ H at React. Temp.	Δ H_{25} in Cal/Mole
$[Na_2CO_3] + [SiO_2]$ Quartz $\rightarrow [Na_2SiO_3] + CO_2$	425-600	22,800	21,720
$[K_2CO_3] + [SiO_2]$ Qu. $\rightarrow [K_2SiO_3] + CO_2$	400-550	29,900	(31,250)
$2\,[KNO_3] + [SiO_2]$ Qu. $\rightarrow [K_2SiO_3] + 2NO + \frac{1}{2}\,O_2$			131,660
$[CaCO_3] + [SiO_2]$ Qu. $\rightarrow [CaSiO_3]$ Woll. $+ CO_2$	420-560	28,000	20,560
$[MgCO_3] + [SiO_2] \rightarrow [MgSiO_3]$			23,850
$[BaCO_3] + [SiO_2]$ Qu. $\rightarrow [BaSiO_3] + CO_2$			{35,650} {37,000}
$[Na_2CO_3] + [Al_2O_3]$ Cor. $\rightarrow 2\,[NaAlO_2] + CO_2$			(72,470)
$[CaCO_3] + [Ai_2O_3] \rightarrow [CaO.Al_2O_3] + CO_2$			37,520
$[Na_2CO_3] + [B_2O_3] \rightarrow 2\,[NaBO_2] + CO_2$			52,980
$[Na_2O] + [SiO_2]$ Qu. $\rightarrow [Na_2SiO_3]$			— 53,800
$[CaO] + [SiO_2]$ Qu. $\rightarrow [CaSiO_3]$	500	{— 14,100 — 19,320}	— 21,910
$[MgO] + [SiO_2]$ Qu. $\rightarrow [MgSiO_3]$			{— 4,800 + (5,700)}
$[PbO] + [SiO_2]$ amorph $\rightarrow [PbSiO_3]$			4,000
$[PbO] + [SiO_2]$ Qu. $\rightarrow [PbSiO_3]$			1,360
$[Al_2O_3]$ Corund. $+ [SiO_2]$ Qu. $\rightarrow [Al_2O_3.2SiO_2]$			15,880
$[Na_2SiO_3] + [SiO_2]$ Qu. $\rightarrow [Na_2Si_2O_5]$	450-600	{— (7,100) — 2,710}	{— (7,260) — 3,100}
$[Na_2SiO_3] + [SiO_2]$ Qu. $\rightarrow (Na_2Si_2O_5)$ glass			+ 5,080
$(Na_2Si_2O_5)$ glass $+ (n—2)\,[SiO_2]$ Qu. $\rightarrow (Na_2O,nSiO_2)$ glass			+ (n—) × 3,280
$[K_2SiO_3] + [SiO_2]$ Qu. $\rightarrow [K_2Si_2O_5]$	about 600	— 11,880	(—13,820)
$[K_2SiO_3] + 3\,[SiO_2]$ Qu. $\rightarrow [K_2Si_4O_9]$	about 450	— 19,360	
$3\,[Na_2Ca(CO_3)_2] + 6\,[SiO_2]$ Qu. $\rightarrow [Na_2Ca_2Si_3O_9] + [Na_4CaSi_3O_9] + 6\,CO_2$	550-530	+174,500	
$[Na_2Ca_2Si_3O_9] + 2\,[Na_4CaSi_3O_9] + 4\,[SiO_2]$ Qu. $\rightarrow [Na_2Ca_3Si_6O_{16}]$	950	+ 22,770	
$[Na_2Ca_3Si_6O_{16}] \rightarrow 3\,[CaSiO_3] + [Na_2Si_2O_5] + [SiO_2]$ Qu.	1000	— 47,270	
$[Na_2SO_4] + 2\,[C]$ graphite $\rightarrow [Na_2S] + 2CO_2$	760-800		+ 51,780
$3\,[Na_2SO_4] + [Na_2S] + 8\,[SiO_2]$ Qu. $\rightarrow 4\,[Na_2Si_2O_5] + 4\,SO_2$			+171,000
$[Na_2S] + [CaCO_3] \rightarrow [CaS] + [Na_2CO_3]$			— 5,830
$3\,[Na_2SO_4] + [CaS] + 4\,[SiO_2]$ Qu. $\rightarrow 3\,[Na_2Si_2O_5] + [CaSiO_3] + 4\,SO_2$			+176,640
$3\,[Na_2Si_2O_5] + 5\,[CaCO_3] \rightarrow 2\,[Na_2Ca(CO_3)_2] + [Na_2Ca_3Si_6O_{16}] + CO_2$	about 600	(— 77,680)	
$[Na_2Ca(CO_3)_2] + [Na_2Ca_3Si_6O_{16}] \rightarrow 2\,[Na_2Ca_2Si_3O_9] + 2\,CO_2$	450-600	+ 51,400	

Inventions and Inventors

Annealing and Tempering

Apparatus for Cooling Newly Molded Glassware. Fig. 1. Patent No. 2,677,919. Filed June 30, 1947. Issued May 11, 1954. Two sheets of drawings. Assigned to Emhart Manufacturing Company by Ralph N. Worrest.

In order to provide greater production speeds with commercial glassware forming machines such as Hartford I. S. Machines, the time of stay at the dead plate is substantially reduced. At one side of the conveyor 2, Fig. 1, and at substantially the same level is a horizontally disposed dead plate comprising sections 3 and 4, respectively, disposed side by side in suitable relation to the conveyor. The dead plate sections 3 and 4 have numerous perforations as indicated at 6 and 7, respectively. These dead plate sections are located over and may constitute the tops of cooling air ducts.

The usual take-out means of the forming machine may be employed to take out each newly formed article from the mold and to deliver such article onto one of the dead plate sections at the cooling station. After a predetermined period of cooling on that dead plate section, the article may be moved laterally by an appropriately timed article transfer means to a second cooling station on the second dead plate section where the article may be subjected to further forced cooling. Thereafter, a second suitably timed article transfer means may operate to transfer the article onto an adjacent conveyor.

The patent contains 4 claims and the following references were cited: 1,900,781, Wardley, Mar. 7, 1933; 2,066,283, Wadman, Dec. 29, 1936; 2,182,167, Berthold, Dec. 5, 1939; 2,282,848, Berthold, May 12, 1942; 2,375,944, Quentin, May 15, 1945; and 2,413,722, Long, Jan. 7, 1947.

Feading and Forming

Pneumatic Control Means for Glass Severing Mechanism. Fig. 2. Patent No. 2,678,519. Filed March 27, 1953. Issued May 18, 1954. One sheet of drawings. Assigned to Emhart Manufacturing Company by William T. Honiss.

The present application discloses novel pneumatic control means which are operatively associated with an air motor so as to assure periodic cutting strokes of the shear blades at uniform time intervals during normal operation of the cutting mechanism. It is a continuation of Serial No. 237,342.

The improved shear mechanism comprises a pair of shear arms 1 and 2, respectively, the free ends of which carry cooperative shear blades 3 and 4, as seen in Fig. 2. The shear arms 1 and 2 are pivotally supported adjacent to their ends opposite the blades for swinging movements about the axes of vertical spindles 5 and 6. These are mounted in tubular holders 7 and 8, respectively, carried by a bracket 9, projecting from one end of a cylinder 10, which forms part of an air motor 11 for operating the shear arms. The air motor 11 is operated by admitting air under pressure to the remote or distal ends of the cylinders 10 and 27 and has a combination air intake and exhaust conduit connected as is conventional, such conduits being elements of a pressure air supply and exhaust system. The timing and pneumatic control means is shown in the lower portion of Fig. 2.

The patent contains 9 claims and the following references were cited: 1,991,705, Schreiber et al., Feb. 19, 1935.

High Torque Shears. Patent No. 2,678,518. Filed July 18, 1951. Issued May 18, 1954. Two sheets of drawings (none reproduced). Assigned to Emhart Manufacturing Company by William T. Honiss.

Charges weighing 28 lbs. or more can be severed from a column of viscous molten glass by glass-cutting shears of the present invention. The severing mechanism has sufficient power to cut through large columns or streams of viscous glass smoothly so as to sever the charges cleanly. The severing mechanism has cooperative shear blades operatively connected to the piston of a fluid pressure actuated motor so as to be closed to sever a stream or column of molten glass issuing downwardly from the outlet of a glass feeder at about the midstroke of the motor piston and to be opened during the remainder of the piston stroke. The mechanism operates under a high torque and is thus able to shear through a thick column or mass of molten glass. The shear blades operate at uniform time intervals and are readily adjusted to variable feeding operations.

The patent contains seven claims and the following references were cited: 1,806,743, Cramer, May 26, 1931; 1,953,030, Sterrett, Mar. 27, 1934; 1,994,123, Curtis, Mar. 12, 1935; 2,158,708, Stuckey, May 16, 1939; 2,218,-

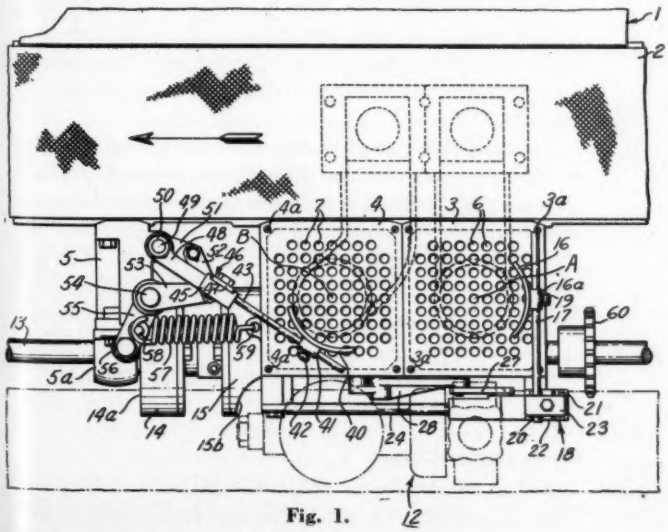


Fig. 1.

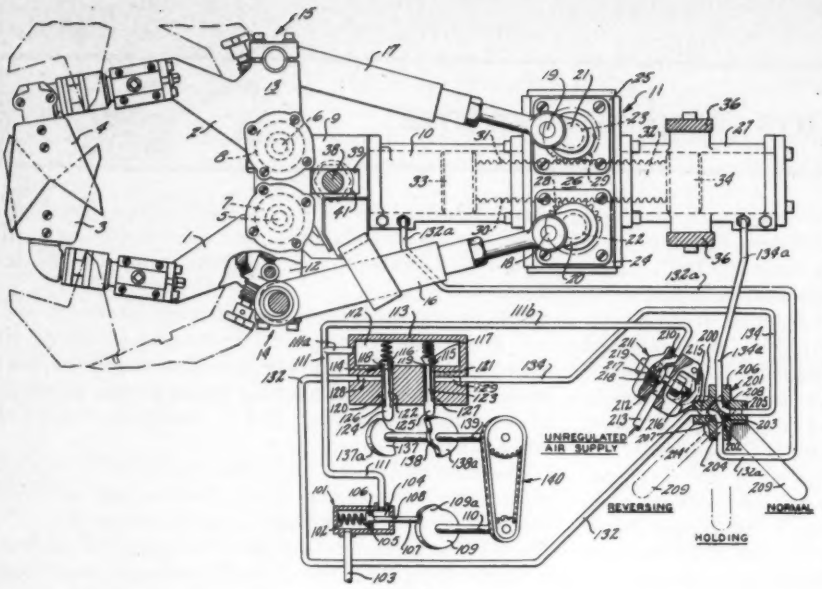


Fig. 2.

970, Honiss, Oct. 22, 1940; and 2,518,871, Craig, Aug. 15, 1950.

Automatic Continuous Press for Molding Glass Articles. Patent No. 2,676,436. Filed March 26, 1951. Issued April 27, 1954. Three sheets of drawings (none reproduced). Assigned to Cristalerias Rigolleau Sociedad Anonima by Carlos F. Zampieri.

This invention relates to an automatic continuous press for molding glass articles under pressure wherein all the movements of the different moving parts of the machine, and also the charging of the molds with molten glass, are brought about by the use of mechanical means operating in time relationship. In order to properly manufacture the molded article and in order that the final quality be of the highest possible order, it is necessary to assure that the charge of molten glass, when introduced into the mold from the automatic feeder, should fall into the mold properly centered.

In the continuous presses, the table or platform is given a constant rotary movement of uniform speed and the mold-supporting plates or turrets are also adapted to rotate at given instants. The movements are so timed that at the moment of charging the molten glass, the mold is effecting two movements, a translational motion in the direction of the rotation of the table and a movement in the opposite direction, due to the circular movement imparted by the mold-supporting disc on which it is mounted. These movements are combined in such a manner that the speed at which the center of the mold moves in one direction due to the movement of the table will be equal but opposite in direction to the speed of the movement caused by the rotation of the mold-supporting disc. In this manner, with the center of the mold subjected to two movements of equal speed in opposite directions, the movements will cancel each other, whereby at the time of charging the mold will remain stationary.

The patent contains 9 claims and the following references were cited: 1,611,155, Bisaillon, Dec. 21, 1926; 2,224,653, Lane et al., Dec. 10, 1940; and 2,393,265, Richardson et al., Jan. 22, 1946.

Furnaces

Glass Furnace. Fig. 3. Patent No. 2,677,003. Filed December 31, 1949. Issued April 27, 1954. Two sheets of drawings. Assigned to Societe Anonyme des Manufactures des Glaces et Produits Chimiques de Saint-Gobain, Chauny & Cirey, by Pierre Arbeit and Pierre La Burthe.

This invention relates to tank furnaces for the manufacture of glass which comprise, at least, two compartments separated from each other by a bridgewall or partition, the molten glass passing from one compartment to the following one either over the partition in the form of a shallow layer or through a submerged orifice formed therein. This arrangement of the furnace enables one to subject the glass in each of the compartments to particular treatments, such as melting or fining, which necesitate different conditions of temperature. By the division of the furnace into distinct compartments, it is possible to reduce the longitudinal convection currents which are known, in tanks not provided with compartments, to carry back the glass from downstream colder zones to upstream hotter zones and to cause a useless consumption of heat.

In the embodiment shown in Fig. 3, two partition walls 14 and 15 are provided. With the sidewalls 4 and 5 they form a little tank 16 which has a bottom 17, the level of which can be and is shown at a height different from that of compartments 2 and 3. A graphite float 18 enters this tank, which is otherwise filled with glass.

The float 18 is maintained submerged by means of U-shaped metal tubes 21 and 22, through which a current of water flows and which rest on the upper surface of the float near its ends. These pipes are adjustable in height to regulate the depth of immersion of the upper part 23 of the float. The heights of the partitions 14 and 15 and float 18 are such that a part of the float is always maintained under the upper part of the walls even when the top of the float is practically at the free surface of the glass.

The advantages given by this arrangement are the following: The walls 14 and 15 limit the longitudinal displacement of the float; a good seal between the two compartments 2 and 3 is obtained with the two partitions. It is possible to cool the glass of the tank 16 from beneath in order to make it more viscous and by thus avoiding any glass current between the walls and the float, this tightness is still increased.

The patent contains 23 claims and 31 references were cited.

Glass Compositions

Optical Glass. Patent No. 2,678,281. Filed May 6, 1953. Issued May 11, 1954. No drawings. Assigned to

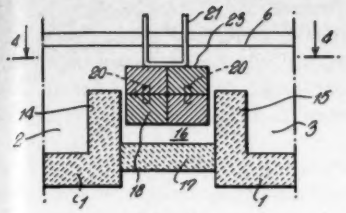


Fig. 3.

Jenaer Glaswerk Schott & Gen. by Walter Geffcken and Gerd Rehs.

Present-day optical glasses with a refractive index n_d greater than 1.70 and a value of the Abbe number v of between 42 and 52 either contain considerable amounts of the expensive tantalum, poisonous berillium or radio-active thorium. They may show an inclination to crystallize, as do glasses with a high content of cadmium oxide (CdO), or else are strongly colored, as for instance glasses with a high percentage of tungsten oxide (WO_3).

Improved optical glasses are shown in the following table:

	1	2	3	4	5	6	7	8	9
SiO_2	5.9	2.0	...	4.0	...	...	4.0	4.0	4.0
B_2O_3	37.6	36.0	37.6	37.3	42.0	41.3	32.7	32.7	32.7
La_2O_3	33.7	25.0	26.7	25.7	26.4	32.4	38.0	26.8	29.0
ZrO_2	7.9	3.0	2.5	7.4	7.8	8.1	7.5	7.5	7.5
PbO	4.0	4.0	11.3	10.7	12.1	6.1	6.8	18.0	15.8
CaO	10.9	5.0	14.5	10.9	11.7	12.1	11.0	11.0	11.0
SrO	...	3.0	...	...	...	...	...	...	...
BaO	...	5.0	...	...	...	...	...	...	...
ZnO	...	17.0	7.4	4.0	...	...	...	...	...
n_i	1.705	1.710	1.717	1.717	1.717	1.720	1.738	1.744	1.744
v	52.0	50.0	47.8	47.9	48.0	50.3	48.5	43.7	44.7

This patent contains 5 claims and no references were cited.

Glass Wool and Fiber

Method of Treating Glass Fiber Bats with Resin and Product. Patent No. 2,676,898. Filed July 22, 1950. Issued April 27, 1954. No drawings. Assigned to Owens-Corning Fiberglas Corporation by Charles J. Folger and Richard M. Roberts.

By removing the catalyst from a resin-forming reaction, a superior binder is provided for glass fibers. This binder is less susceptible to alkali attack, less likely to swell and disintegrate, and hence provides superior resistance to weathering.

A procedure is carried out in which phenol is reacted with formaldehyde in the molar ratio 1:2.2, respectively. The catalyst is sodium hydroxide and is present in the amount of 2.5% based on weight of phenol. Ordinarily, the amount of catalyst may range from 1 to 5%. After being heated for two hours at 160°F. to 170°F., the mixture is cooled to 140°F. to 150°F. At this point, heating is continued until a desired point is reached as conventionally determined by water tolerance, specific gravity and refractive index.

The resin is then neutralized with a 1:1 water solution of sulfuric acid to a pH of 7.5 as determined by conventional pH meter. Subsequently, the resin is sprayed on a bat of glass fibers arranged in a helter-skelter, jackstraw pattern and then advanced to a final or "C" stage of polymerization by heat. The resulting bond shows excellent resistance to attack from alkalies even in atmospheres of high humidity. Further, when the resin is cured while the bat is under compression, there is no subsequent swelling or expansion of the bat under conditions which previously caused destruction of the resin bond.

The patent contains 2 claims and the following references were cited: 1,222,980, Ornstein, Apr. 17, 1917; 1,858,168, Ostersetzer et al., May 10, 1932; 1,960,116, Loos, May 22, 1934; 2,140,981, Booty et al., Dec. 20, 1938; 2,252,157, Bergin et al., Aug. 12, 1941; 2,305,417, Hansen, Dec. 15, 1942; 2,325,302, Britt, July 27, 1943; 2,349,909, Meharg, May 30, 1944; and 2,493,194, Neino, Jan. 5, 1950.

Retainer and Separator Mats for Storage Batteries. Patent No. 2,677,007. Filed February 3, 1949. Issued April 27, 1954. One sheet of drawing (none reproduced). Assigned to Owens-Corning Fiberglas Corporation by Meredith St. George Jensen.

In the manufacture of storage batteries, it is necessary to space the negative and positive plates. One of the major disadvantages of the various types and character of separator heretofore used is that if the separators are formed so as to snugly engage the positive plates in a manner to prevent shedding of the active material, the intimate surface contact of the separator decreases the effective action of the electrolyte by impairing the free flow of electrolyte into contact with the positive plate. This condition increases the internal resistance of the battery with a consequent corresponding decrease in efficiency of the battery.

The object of the invention is the provision of a composite mat of glass fibers arranged in a manner suitable for use as an insulator in storage batteries wherein one surface that engages a battery plate is replete with very small pores for effectively retaining the active material on the plates. The interstices between adjacent glass filaments or fibers on the other hand facilitate the flow of electrolyte while retaining the active material to promote efficient operation of a battery.

The patent contains 10 claims and 16 references were cited.

Sheet and Plate Glass

Apparatus for Bending and Tempering Sheets of Glass. Fig. 4. Patent No. 2,677,918. Filed April 29, 1949. Issued May 11, 1954. Six sheets of drawings. Assigned to Societe Anonyme des Manufactures des Glaces & Produits Chimiques de Saint-Gobain by George William Terence Bird, John Dennett and Edward M. S. Wood.

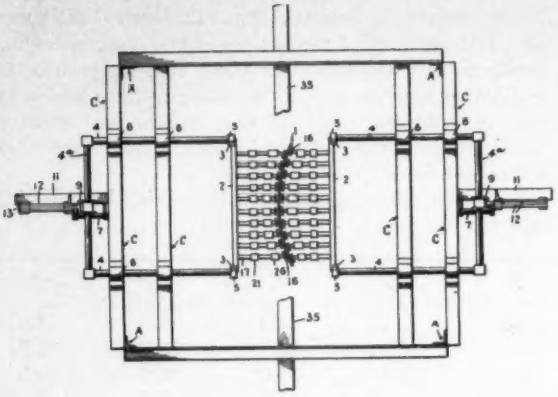


Fig. 4.

This invention relates to the art of manufacturing bent sheets of glass. The main object of the present invention is to provide an improved form of an adjustable apparatus, whereby smooth, simple bends of various forms can be obtained and, moreover, from the same apparatus compound bends can be produced.

Fig. 4 shows apparatus constructed with opposed banks of shaping pads carried on telescopic members. Each group of shaping pads is mounted in a horizontal bar 2 and the plurality of bars are parallelly arranged. Above and below the center of each bar 3 is an actuating shaft 4 connected to the bar by a bracket 5, and the shafts pass through bearings 6 carried on cross bearers C of the framework.

The reciprocating movement of the shafts 4 is effected by hydraulic means of which the double acting cylinders are indicated at 7. The shafts 4 are coupled as shown by rods 4a and the pair of rods 4a of each grid is connected to the respective piston, by levers 9 on fixed members 11, and links 12. An outward movement of the pistons causes the grids carrying the pads to retract from the glass 1 and when the pistons are actuated inwardly, the carriers are moved towards one another to impart a predetermined bend on a flat sheet of hot glass disposed between them.

The patent contains 12 claims and 12 references were cited.

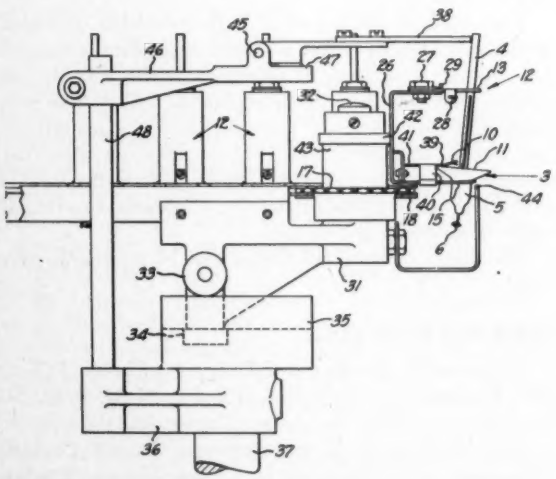


Fig. 5.

Tube and Cane Machines

Exhaust Tube Crack-Off Device. Fig. 5. Patent No. 2,676,437. Filed October 30, 1951. Issued April 27, 1954. One sheet of drawings. Assigned to General Electric Company by Arthur P. Russell and John H. Hollopetre.

Apparatus for cracking-off an excess end portion of a vitreous exhaust tube extending from a mount for a lamp, radio tube or other electrical device is shown in Fig. 5. The crack-off operation occurs during the advancing translational movement of a conveyor toward the loading position when the head 12 is carried toward an abutment or crack-off member in the form of the stationary finger 38 to press the upper end portion of the exhaust tube 4 against finger 38. The advancing motion in the conveyor brings the end of the stationary finger 38 against the side of the exhaust tube 4 containing the notch or score 10 and produces a bending pressure against the exhaust tube 4 which applies a rupturing strain in the notched area.

The success of the operation is dependent upon proper wedging of the mount 3 at a fixed position in the holder 15 during the initial movements of the movement of the exhaust tube 4 against the finger 38 when the mount 3 is tilted to an extent that the rim 11 of the stem tube 5 seats against the overhanging lip 39 of the holder 15. The pressure of the finger 38 against the upper end portion of the exhaust tube 4 first forces the exhaust tube 4 from between the jaws 13 and 14 and then tilts the mount 3 to an extent that the rim 11 of the stem tube 5 is forced against the lip 39 of the holder 15 and the supporting legs 40 for the lip 39. All portions of the holder 15 remain in fixed position during the crack-off operation.

The patent contains 3 claims and the following references were cited: 1,315,799, Suman, Sept. 9, 1919; 1,698,321, Staudenmeir et al., Jan. 8, 1929; 2,362,115, Cline, Nov. 7, 1944; 2,494,674, Smith et al., Jan. 17, 1950; and 2,535,630, Gartner et al., Dec. 26, 1950.

Automatic Shank Wire Inserting Device. Fig. 6. Patent No. 2,676,435. Filed March 27, 1953. Issued April 27, 1954. Two sheets of drawings. Assigned to Westinghouse Electric Corp. by Ferdinand W. Gillman.

In the manufacture of incandescent lamps, the tungsten wire becomes somewhat soft and pliable when heated to incandescence, and the filament coils may then be distorted or broken if the lamp is subjected to shock or vibration while burning. A specific object of the present invention is a magnetic shank holding jaw for securing a shank wire in the proper position at an unloading and loading station without interfering with the unloading and other loading operations.

As shown in Fig. 6, the downward motion of the plunger 32 opens the movable jaws 47 and 48 to permit the loading of a filament support arbor 54 into the spring biased upper arbor holding jaws 64, and against the stationary stop 92, thus centralizing and position-

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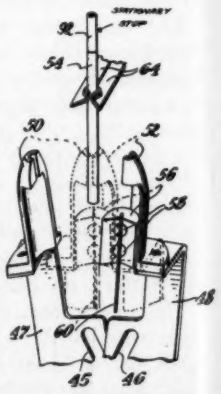


Fig. 6.

FIFTEENTH CONFERENCE ON GLASS PROBLEMS

The Fifteenth Conference on Glass Problems has been announced for December 2 and 3 to be held at Ohio State University, Columbus, Ohio. The headquarters hotel will be the Hotel Deschler-Hilton.

Emphasis this year will be on electrical application to both melting and annealing, but other subjects will also be covered.

L-O-F ISSUES GARAN LICENSE

A license to use the exclusive Garan finish for fiber glass cloth has been issued by Libbey-Owens-Ford Glass Company to Fothergill & Harvey, Ltd., Littleborough, Lancashire, England, weavers of glass fabrics. This is the first foreign licensee for the process which is used to give high wet strength retention and other important characteristics to industrial glass cloth used in the reinforcement of plastics.

Announcement of the British license was made jointly by Don W. Lyon, Manager of fiber glass textile sales for L-O-F, and Bert Taylor, of the British firm's research and development department.

Four finishers of fiber glass cloth in the United States have also been licensed to use the Garan process. They are United Merchants Industrial Fabrics Corporation, Hess, Goldsmith & Company, Inc., Bigelow Fiber Glass Products Division of Bigelow-Sanford Carpet Company, Inc., and T. E. Thal, Inc.

PPG ERECTS NEW GLASS PLANT

Ground was recently broken for Pittsburgh Plate Glass Company's new $34,000,000 plate glass producing plant in Cumberland, Maryland. Designed for straight line production, the plant will be nearly three-quarters of a mile in length.

Harry B. Higgins, President, turned the first shovel of earth at the plant site located three miles below Cumberland on the Potomac River. Richard B. Tucker, Executive Vice President of the firm, served as master of ceremonies at the groundbreaking program.

Engineering on the plant, designed to produce the finest plate glass of precision optical quality, will be completed later this year. Officials of the firm estimated that two years will be required to get the ultra-modern facility in operation. Approximately 1,000 employees will be required to staff the planned production facilities.

At the ceremonies, Mr. Higgins stated that the new Cumberland plant will utilize new techniques in plate glass manufacture and said that the plant will have features not now in any plate glass plant in the world.

MINNEAPOLIS-HONEYWELL BUYS HEILAND RESEARCH COMPANY

Minneapolis-Honeywell Regulator Company has purchased the assets of Heiland Research Corporation, manufacturer of precision scientific instruments and high quality photographic flash equipment.

The 20-year old Denver firm will be operated as a new Honeywell division. The Heiland part of the name will be retained. The new division will continue to operate from its Denver plant and offices, with present production, administrative and sales personnel.

CORNING DEVELOPS DOSIMETER

A locket-size glass device that records the radiation to which it is exposed in an A-bomb war was made available recently by Corning Glass Works.

Weighing less than an ounce, the device, known as a dosimeter, is small enough to fit a watch pocket or it can be worn as a locket. Through its use, medical diagnosis can be aided in examining victims of an atomic attack. It can measure from doses as small at 10 Roentgens (the unit of measure), which is below the danger limit, up to several thousand Roentgens. It survives shock, immersion and temperature tests, and has an indefinitely long life.

The heart of the dosimeter is a piece of silver-activated phosphate glass enclosed in a locket. It permanently records the radiation received, making it possible to measure the amount immediately or weeks after exposure by use of an auxiliary reading instrument, known as a fluorophotometer or "reader". When illuminated by ultraviolet light in the reader, the phosphate glass emits fluorescent orange light in amounts proportional to the exposure the glass absorbed. Measuring the intensity of the orange light thus gives the measure of the dose. The reader, which can measure approximately 150 dosimeters an hour, does not require personnel with previous training to operate it.

Basic research and initial development of the locket-type dosimeter was conducted by the Naval Research Laboratory. The U.S. Navy Bureau of Ships sponsored further governmental and industrial development of both the dosimeter and reader.

DELOS M. PALMER EXPANSION

Delos M. Palmer, Director of Delos M. Palmer & Associates, has announced the completion of expanded facilities for the design of products, special machinery, and erecting and testing of special machines.

New equipment includes a drafting room and a mechanical laboratory with a traveling bridge crane for the assembly of large machines. New lighting and air-conditioning has been installed throughout the entire headquarters.

The new addition is the result of the rapid growth of automation and a desire to provide a complete engineering service for their clients.

Some Special Fiber Glass Compositions

A report by Thomas D. Callinan and Robert T. Lucas on the Electrical Properties of Glass Fiber Paper, II (*Naval Research Laboratory Report 4042*, October 30, 1952, U. S. Dept of Commerce, Office of Technical Services, Washington 25, D. C.) gives considerable technical information regarding the use of superfine glass fibers in filter papers, dielectric papers and other nonflammable products. However, of greater interest to glass technologists is the data given in Appendix B of this report which deals with the results of experimental work conducted under contract by a manufacturer of glass fibers.

Nine problems were investigated: (1) the possibility of commercially producing glass fibers having average diameters of the order of 0.1 micron; (2) the change of the technology of the fiber forming process so as to increase the yield of the glass fiber per unit of time or to amend the techniques and produce superior fibers; (3) prepare fibers possessing greater thermal stability than those made from Pyrex-E; (4) prepare fibers having compositions similar to that of asbestos with the object of duplicating qualities possessed by asbestos for gasket and packing applications and not possessed by the presently available glass fiber; (5) prepare fibers containing no element having high-capture tendencies for thermal neutrons (among other things this would eliminate the use of boron in standard glass); (6) prepare fibers containing elements having toxic qualities towards bacteria with the object that such fibers might be employed in places where bacteria and fungi might prove dangerous; (7) prepare copper-bearing glasses with the object of later reducing these by the action of hydrogen which will yield conductive glass fibers suitable for exploitation in radar problems; (8) prepare boron-, lead- and cadmium-bearing glass fibers for use as lightweight shields against thermal neutrons and gamma radiation; (9) prepare fibers which could be made into paper having a tensile strength different from that obtained when fibers of identical diameter made from Pyrex-E were employed.

The investigation of these problems involved four steps: (1) the judicious formulation of glass forming constituents, including in some cases the incorporation of elements suggested for a specific application, e.g., cadmium in the nuclear application and silver in the toxicological one; (2) the effective melting of these formulations and the evaluation of the cooled item as a glass suitable for fiberization; (3) the conversion of the glass into an experimental quantity of fiber from which its fibrous qualities might be determined; (4) the develop-

TABLE I.

Special Fiber Glass Compositions

No.	SiO_2	R_2O_3	CaO	MgO	BaO	Na_2O	K_2O	Li_2O	B_2O_3	P_2O_5	Sb_2O_3	As_2O_3	CuO	AgO	CoO	CdO	PbO	ZnO	MnO_2	TiO_2
221	96.3	...	...	...	...	...	...	...	3.0	...	...	...	...	...	...	...	...	...	...	...
224	8.6	.2	.9	4.8	...	...	...	5.4	80.1	...	...	...	...	...	...	...	...	...	...	...
240	2.1	...	25.2	.6	...	.6	...	...	4.6	67.0	...	...	...	...	...	...	...	...	...	...
245	53.5	13.0	6.8	4.0	...	.4	...	...	12.0	...	...	...	...	10.0	...	...	...	...	...	...
246	51.0	...	...	...	...	...	...	...	25.0	...	...	...	...	...	...	...	24.0	...	...	...
250	70.0	2.0	...	...	...	1.0	2.0	3.0	22.0	...	...	...	...	...	...	...	...	...	...	...
252	52.5	13.5	1.3	...	...	.4	...	...	12.1	...	...	...	...	...	...	20.2	...	...	...	...
253	58.0	9.0	...	30.0	...	...	...	2.0	...	...	...	...	...	...	...	...	...	...	...	...
254	53.5	14.1	7.3	3.0	...	1.2	2.5	.7	...	...	...	...	17.9	...	...	...	...	...	...	...
255	49.3	12.9	6.7	2.8	...	1.1	2.3	1.3	...	...	...	...	20.7(?)	...	...	...	...	.8	...	2.1
256	47.8	14.6	6.5	2.7	...	1.1	2.2	1.3	1.1	...	...	...	20.0	...	...	...	...	.8	...	2.0
257	48.7	12.8	6.7	2.7	...	1.1	2.3	1.3	...	...	...	...	20.4	...	...	...	...	4.1	...	4.1
258	48.7	12.8	6.7	2.7	...	1.1	2.3	1.3	...	...	...	...	20.4	...	...	...	...	3.9	3.9	...
259	46.9	12.3	6.4	2.6	...	1.0	2.2	1.3	...	...	...	...	19.7	...	...	...	...	3.9	3.9	...
260	46.2	12.1	6.3	2.6	...	1.0	2.1	1.2	...	...	...	...	19.4	...	1.0	...	...	...	...	...
261	38.7	5.5	...	...	...	...	...	...	27.8	...	...	...	...	...	...	...	27.7	...	...	...
262	51.0	14.0	...	.2	...	1.0	...	...	11.0	...	...	...	22.8	...	...	...	...	...	...	...
265	79.4	...	1.6	...	...	1.2	...	1.1	15.1	...	1.7	...	...	...	...	...	...	...	...	...
267	61.3	2.0	20.2	...	.4	15.7	...	...	...	...	...	...	...	...	...	...	...	...	...	...
268	89.5	.2	.6	.5	...	2.0	...	2.4	...	4.9	...	...	...	...	...	...	...	...	...	...
269	61.3	3.8	19.5	...	.4	15.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
270	61.0	5.5	18.8	...	.4	14.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
277	66.5	12.3	10.5	...	...	10.3	...	...	...	...	...	...	...	...	...	...	...	...	...	.9
278	58.5	12.3	18.4	6.7	...	.5	2.7	...	...	...	...	...	...	...	...	...	...	...	...	...
279	61.4	...	2.0	...	...	36.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
284	49.7	14.6	21.5	.4	...	.9	...	...	11.2	1.3	...	.5	...	...	...	...	...	...	...	...
285	46.0	15.7	18.8	.3	...	1.0	...	...	14.0	4.1	...	.7	...	...	...	...	...	...	...	...
286	...	1.5	...	...	38.0	...	...	...	3.0	56.0	{CaO+ P_2O_5}	1.5	...	...	...	...	...	...	...	...
287	...	20.3	(Al_2O_3)	...	...	28.3	...	...	51.0	...	...	...	...	...	...	...	...	...	...	...
288	...	32.3	"	...	...	24.0	...	...	43.5	...	...	...	...	...	...	...	...	...	...	...
289	...	42.3	"	...	...	20.5	...	...	37.1	...	...	...	...	...	...	...	...	...	...	...
291	53.6	14.6	15.2	5.0	.6	.7	.1	...	10.3	...	...	...	...	...	...	...	...	...	...	...
292	50.7	13.2	1.1	...	...	.3	...	...	9.9	...	...	...	...	...	...	24.6	...	...	...	...
293	47.2	12.3	1.0	...	...	.3	...	...	9.2	...	...	...	...	...	...	30.0	...	...	...	...
295	50.8	14.3	10.0	...	...	.4	...	...	10.7	...	...	...	...	...	...	...	...	9.8	...	...

ment of an experimental fibrous glass into a production item suitable for specific use.

Of the many compositions prepared, not all were glasses in the strict sense of the word, and these were discarded when failure was met. Of the 84 melts with glass-like properties, each was placed in a fiberizing unit consisting of a furnace, crucible, flame blower and receiving screen. Based on past experience and know-how, tentative conditions, such as temperature and flame velocity, were established. Fifty-seven of the 84 melts were made successfully into fiber.

Examination of the chemistry of the melts shows that it is possible to make glass fiber compositions containing as much as 80.1% boric oxide (Glass 224 in Table I), a quantity eight times as much as is now available in Pyrex-E glass. Also, melts have been spun successfully into fiber which are high in silica (Glass 221, 96.3%), phosphoric oxide (Glass 240, 67.0%), alumina (Glass 289, 42.3%), magnesia (Glass 253, 30.0%) and soda (Glass 279, 30%).

In terms of each of the objectives previously listed, the following results are given:

(1) Fibers having an average diameter less than 0.1 micron have been successfully made on commercial equipment from a composition corresponding to Pyrex-E.

(2) Changes in glass fiber technology and improvements in manufacturing details based on experience gained by quantity production runs have resulted in increased yields of glass per unit time with subsequent cost reduction and logistic improvement.

(3) Fibers possessing thermal stabilities in excess of 1500°C. and diameters of the order of 0.2 micron have been produced successfully as a result of the program. Known commercially as "Quartz Fiber", it is a hydrous silica fiber which can be transformed into anhydrous silica, quartz and cristobalite by heat treatment at 600, 1000 and 1500°C., respectively. Efforts are now underway to produce hydrous alumina fibers by the action of acid on such fibers as those produced from Glasses 287, 288 and 289.

(4) Fibers possessing a composition similar to thermally-desiccated asbestos (Glass 253) have been prepared successfully. Such a fiber, although soft when fine, did not possess all the qualities found in natural asbestos. This was due probably to the absence of water of hydration.

(5) Boron and lead-free glass fibers (Glasses 267 through 270, 277 through 279) and silica fibers have been prepared for use where thermally stable materials containing these elements might prove hazardous.

(6) Copper-bearing glasses (Glasses 250, 254 through 260, and 262) were fiberized successfully, and the feasibility of producing glass fibers having relatively high copper oxide contents (20%) was demonstrated. On being subjected to a temperature of 1000°C. in a hydrogen atmosphere, migration of the copper ion to the surface was observed and the formation of a layer of copper oxide on the periphery of the fiber was noticed when it cooled.

(7) Glass fibers possessing qualities which suggest their usefulness as lightweight shields against thermal neutrons have been spun successfully into fibers from melts high in boron (Glass 224) and containing cadmium (Glasses 252 and 291 through 293). For exploitation as thermal blankets and protective shields against beta radiation, glass fibers containing lead (Glasses 246, 261 and 280) have been prepared successfully.

(8) Silver (Glass 245), arsenic (Glasses 284 through 286 and antimony-bearing glasses (Glasses 265 and 298) have been fiberized. While they have not been evaluated in terms of their toxicological qualities, enough is known of the feasibility of making the fibers to warrant pilot plant quantities being produced for evaluation as fungi-resistant insulating papers or bacteria-killing filter papers.

These results indicate that a great variety of novel and exploitable fibers can be produced. The interested engineer may now judge the fiberizing tendencies of certain melts and, hence, the possibility of adjusting the chemistry of glass fibers to the solution of his problem.

F. G. PASOTTI JOINS ELDRED

F. George Pasotti has joined the staff of The Eldred Company, Columbus, Ohio.

Formerly Chief Mechanical Engineer and later Director of Development of Ball Brothers Company, Mr. Pasotti had been with the glass container firm for 19 years.

Born and educated in London, England, Mr. Pasotti served as an engineer in the glass industry in England and Europe before coming to the United States to join the Ball organization.

NEW CONTROL LABORATORY AT AMERICAN POTASH

A new, $150,000 dust-proof and air-conditioned control laboratory has been completed and put into operation at American Potash & Chemical Corporation's main plant at Trona, California.

The two-story structure, measuring 60 feet long and 40 feet wide, is an all-metal windowless building constructed by Stearns-Rober Manufacturing Company, Incorporated in the equipment are the latest safety and convenience devices for use in the testing of chemicals.

Function of the control laboratory is constant testing of chemical solutions before, during and after their processing at the production plant. To accomplish this, the control laboratory conducts approximately 60,000 individual tests per month.

WESTINGHOUSE NAMES MANAGER TUBE DIVISION

Richard T. Orth has joined Westinghouse Electric Corporation to become Vice President in charge of the company's Electronic Tube Division, according to an announcement by J. M. McKibbin, Vice President in charge of Consumer Products.

Mr. Orth, formerly with Radio Corporation of America, succeeds E. W. Ritter, who continued as a consultant to the company.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during July 1954 was as follows: *Flat Glass:* An increase of 2 per cent was shown in the preliminary employment figure of 25,400 when compared with the previous month's adjusted 24,900. *Glass and Glassware, Pressed and Blown:* The preliminary 73,500 persons reported employed during July were 5.2 per cent below the adjusted 77,600 reported for June. *Glass Products Made of Purchased Glass:* A preliminary figure of 12,900 was reported for July. This is 2.2 per cent below the adjusted 13,200 reported for the previous month.

Payrolls in the glass industry during July were: *Flat Glass:* A rise of 2 per cent was shown in the July preliminary payrolls of $10,644,547 when compared with the previous month's adjusted $10,427,456. *Glass and Glassware, Pressed and Blown:* July preliminary payrolls were reported at $22,129,727. This is 5.2 per cent less than the adjusted June payrolls of $23,353,720. *Glass Products Made of Purchased Glass:* A preliminary figure of $3,359,590 was reported for July which is .7 per cent higher than the adjusted June figure of $3,334,188.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	August, 1954
Foods	1,098,000
Medicinal & Health Supplies	1,141,000
Chemicals, Household & Industrial	844,000
Beverages, Returnable	431,000
Beverages, Non-returnable	94,000
Beer, Returnable	139,000
Beer, Non-returnable	761,000
Liquors	609,000
Wines	341,000
Toiletries & Cosmetics	775,000
Sub-total (Narrow)	6,233,000

Wide Mouth Containers

Foods	*3,558,000
Dairy Products	286,000
Medicinal & Health Supplies	381,000
Chemicals, Household & Industrial	179,000
Toiletries & Cosmetics	215,000
Packers' Tumblers	166,000
Sub-total (Wide)	4,785,000
Total Domestic	11,018,000
Export Shipments	213,000
TOTAL SHIPMENTS	11,231,000

* This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production August 1954	Stocks August 1954
Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics	Narrow Neck	4,109,000	4,781,000
	Wide Mouth	*4,141,000	*4,441,000
Dairy Products		285,000	305,000
Beverages, Returnable		501,000	1,405,000
Beverages, Non-returnable		120,000	240,000
Beer, Returnable		169,000	470,000
Beer, Non-returnable		811,000	899,000
Liquors		731,000	1,171,000
Wines		368,000	483,000
TOTAL		11,386,000	14,360,000

* This figure includes Fruit Jars and Jelly Glasses.

Glass container production, based on figures released by the Bureau of Census, for August 1954 was 11,386,000 gross. This is 5.3 per cent higher than the 10,810,000 gross reported for July. During August 1953, production was 11,489,000 gross, or .8 per cent higher than for August this year. Total glass container production at the close of the January-August period has reached 86,188,616 gross. This is 3.5 per cent ahead of the 83,207,614 gross produced during the corresponding period in 1953.

Shipments of glass containers during August rose to reach 11,231,000 gross. This is 11.1 per cent higher than the 10,105,000 gross shipped during July. During August 1953, shipments were 10,867,000 gross, or 3.3 per cent below August this year. Thus far in 1954, glass container manufacturers have shipped a total of 82,398,195 gross. This is 1.2 per cent higher than the 81,368,100 gross shipped during the corresponding period of 1953.

Stocks on hand at the close of August 1954 were 14,360,000 gross. This is .2 per cent higher than the 14,329,000 gross on hand at the end of July and 28.2 per cent higher than the 11,193,000 gross on hand at the end of August 1953.

Automatic tumbler production during July 1954 was 3,943,087 dozens. This is 20.5 per cent below the 4,962,647 dozens produced during June. Production during July 1953 was 3,861,007 dozens. Shipments during July also fell off to 4,615,737 dozens. This is 14.5 per cent below June shipments of 5,398,843 dozens. Shipments during July 1953 were 4,930,961 dozens. Stocks on hand at the end of July 1954 were 8,751,362 dozens, or 1.1 per cent less than June stocks of 8,850,147 dozens. Stocks at the end of July 1953 were 9,952,927 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware fell off 7.8 per cent during July to 2,605,881 dozens. June sales were 2,826,791 dozens. During July 1953, sales were 2,739,149 dozens. At the close of the 12-month period ending July 1954, total sales reached 37,471,170 dozens. This is 9.7 per cent less than the 41,533,965 dozens sold during the same period in 1953.

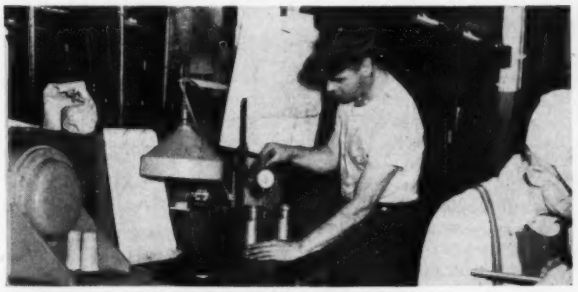
• Basic Refractories Inc. has been announced as one of the 23 recipients of the "Second Annual Saturday Review Awards" for distinguished advertising in 1953. The award is presented ". . . to recognize annually national advertisements which best serve the public interest, and which most searchingly document the continuing miracle of America".

many eyes, many gauges . . .

check every Overmyer mould

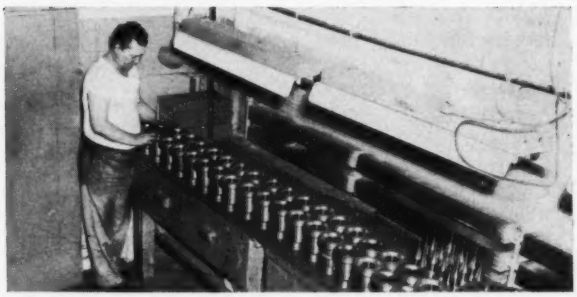
Primary Inspection of Rough Castings

Floor Inspection of First Machine Operation



Continuous Inspection with Precision Instruments

Precision Testing of Tolerances



Final Inspection of Measurement Specifications

Through every phase, every operation—from the raw casting to the shipping room, each Overmyer mould must pass rigid inspection. Aided by many scientific testing devices and gauges, the exacting eyes of trained inspectors seek out any flaw or variation so that every mould meets the specified high standards of the Overmyer Mould Company.

Testing devices, some specially designed for mould equipment, are used in the many step-by-step inspections. To maintain a quality control program assuring the glass industry trouble free moulds conforming to each customer's exacting specifications, is an Overmyer Objective.

Overmyer

A PART IN THE PROGRESS OF GLASS

MOULD COMPANY, INC.

General Offices, Main Plant and Foundry Division: Winchester, Indiana
Eastern Plant: Greensburg, Pennsylvania
Western Plant: South Gate, California

Number 11 in a series of advertisements describing Overmyer Objectives

New Equipment and Supplies

AUTOMATIC LAMP MACHINE

Eisler Engineering Company, Inc., Newark, New Jersey, has recently developed an improved, high-speed sealing machine for miniature or standard photo flash lamps, vacuum gas filled lamps and radio tubes. The new model, 57-MX-D, called the "Seal-Ex", also exhausts the air before sealing and has a production rate of 1600 to 1800 per hour.

The "Seal-Ex" is almost fully automatic, with only a single operator needed to handle it with ease. Sturdily built and compactly designed, its net weight is 2,000 lbs. with dimensions of only 60″ x 60″ x 60″, much less than older models, according to the company's report. A ¾ H.P. motor is all that is necessary to power it.

Bulbs are fed automatically into both sealing and exhaust positions, the latter being equipped with compression rubber heads which tighten or release automatically. Exhaust ports are opened only when a bulb has been transferred into the compression head.

GRINDING SEGMENT ADHESIVE

Chemical Development Corporation, Danvers, Mass., has recently developed a new adhesive for the reclaiming of grinding segments, similar to those used on grinding machines. The new low-cost method of salvaging segments is extremely simple and has already resulted in substantial savings for several companies who have been testing this product over extended periods of time, the manufacturer has reported.

Called Gaff Bond 334, it is simply applied to the surface of the stones. The segments are clamped together with two "C" clamps for 48 hours, and then returned to the grinder for reuse. No heat or pressure is required. The process can be continued indefinitely with no segment loss.

The cemented joint does not interfere in any way with grinding. Safety tests have been made using insulators for the trial. In a straight pull test, the insulators gave way at 15,000 lbs. with the cement remaining sound. Segments have also been successfully tested on production items at four times normal down-feed.

pH INSTRUMENTATION SYSTEMS

The Bristol Company, Waterbury 20, Conn., has announced complete systems for pH recording and control incorporating, for the first time, the new Beckman Model W amplifier.

These pH instrument systems include a Bristol electronic Dynamaster potentiometer recorder or controller, a Beckman Model W amplifier, electrode assemblies in either flow or immersion types, and a variety of final control elements for the addition of gaseous, liquid, solid or slurried reagents.

VARI-PRESSURE BURNERS

Hauck Manufacturing Company, 124-136 Tenth Street, Brooklyn 15, New York, has announced a new line of series #620-P Vari-Pressure low pressure air type burners for either oil or combination oil and gas. They are intended for multiple burnered furnaces, ovens, kilns, etc., where a group of burners are to be operated from one point to ratio and control the capacity of air and fuel by means of varying the pressures.

Single valve control of air-oil ratio and capacity is obtained with a control valve in the combustion air line serving a group of burners. The varying air pressure is then cross-connected to an air-oil ratio regulator for integrated varying of pressures.

By means of a flame adjusting lever, the flame of these burners can be easily and instantly changed from a short, bushy shape to a long, narrow type or intermediate points. The flame lever has an indicator dial and a lock nut.

CATALOGS RECEIVED

The Neff & Fry Company, 194 Elm Street, Camden, Ohio, has compiled a 29-sheet technical brochure on concrete stave storage bins (silos).

The brochure contains a table of cubic foot weights of flowable materials; bin capacities per foot of height; description of wall construction; information on super-concrete stave with test data; detailed drawings of stave, rods and lugs; specifications and drawings of concrete roof; photo of foundation curb on common roof of adjacent bins for supporting superstructures; photos of access opening and trap door in roof; details of 45° elevated floor and overflow partition; details of exterior safety ladder; details of wall openings, including gates, frames and chutes; details of boiler-house coal bins; photos of typical installations.

The Hays Corporation, Michigan City, Indiana, has announced a 4-page folder which gives specifications for the fully automatic, all-electric metering type packaged control for shop assembled boilers.

A schematic drawing shows a typical packaged control system for a combination oil- and gas-fired boiler.

Libbey-Owens-Ford Glass Company, Dept. R-1, 608 Madison Avenue, Toledo 3, Ohio, has issued a new booklet, "So Many Ways to Modernize — With Glass", which suggests ideas on how to modernize, add space, brighten and improve homes using various forms of clear and patterned glass.

The well-illustrated 12-page booklet shows many practical applications of glass products in home modernization among which is a description of how to use panel window sizes of Thermopane insulating glass to turn a porch or breeze-way into an extra year-round room with a minimum of cost and labor.

Cambridge Wire Cloth Company, Cambridge, Maryland, has issued Bulletin 110 devoted to "Automation".

The folder illustrates and describes the application of automation in glass plants, ceramic plants, chemical industries, metalworking and food processing. Construction features of Cambridge woven wire conveyor belts are given and other catalogs are offered.

Harbison-Walker Refractories Company, Farmers Bank Building, Pittsburgh 22, Pa., has published two new bulletins devoted to two types of high temperature, cold setting bonding mortars—Harwaco Bond and Thermolith.

Harwaco Bond consists of hard calcined high-alumina minerals and plastic bonding constituents. Its properties include high refractoriness and nonshrinking characteristics.

Thermolith consists of finely ground chorme ore, chemical binders and a plasticizer. It is an all-purpose bonding mortar that is especially suited for use with the basic refractories such as chrome, magnesite and forsterite brick.

Westcott Chuck Company, Oneida, New York, is distributing a 4-page folder featuring its glassworking chucks.

Amply illustrated, the folder describes the glassworking chucks, listing the various features and advantages. Complete specifications are given, with prices, for the 5-inch, 8-inch, 11-inch, 16-inch and 21-inch chucks.

Geo. P. Reintjes Company, 2517-19 Jefferson Street, Kansas City 10, Missouri, has issued Bulletin 554 describing their sectionally supported roof arch for circular furnaces.

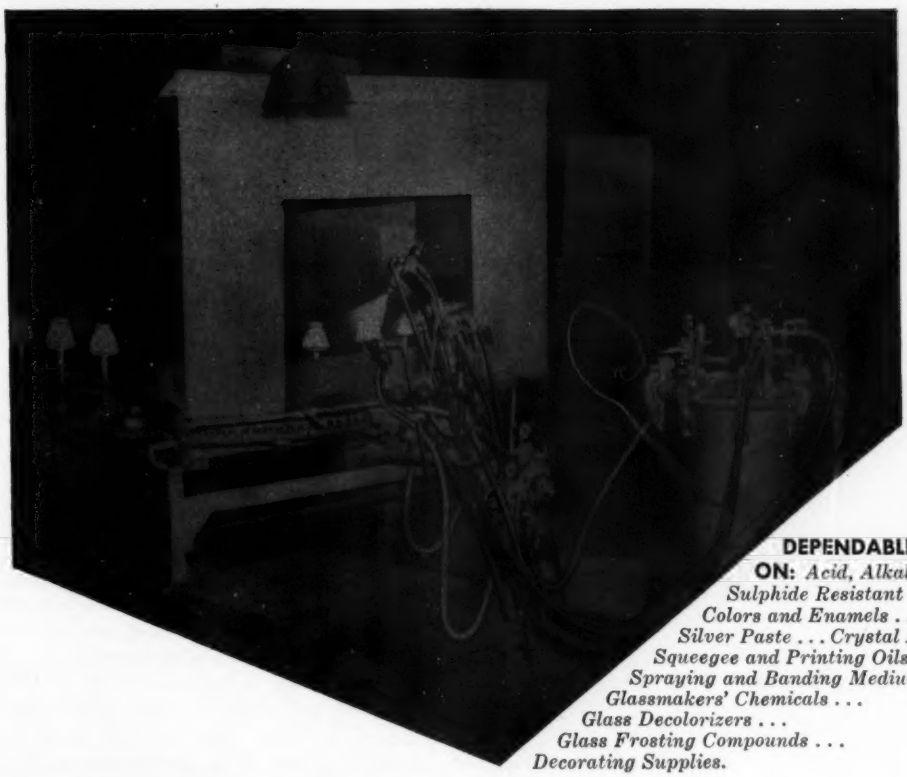
The same "PI" shaped and the same rectangular shaped tiles are used to roof any rotary hearth furnace from 10′ to 100′ diameter without additional refractory or casting shapes. With this type of roof, recesses can be formed in the walls before erecting any of the roof tiles. The recess or offset in the wall into which the roof extends is uniform in cross-section around the entire perimeter of the furnace. The supporting steel can be so located that the distance between the roof and hearth can be varied for the pre-heating, heating and cooling zones.

HIGH OPACITY EXTENDS COVERAGE OF DRAKENFELD SPRAY COLORS

It is no secret why every pound of Drakenfeld Spray Color goes much further than you'd ordinarily expect. We know from long experience how to provide tops in opacity without sacrifice of gloss, and at minimum firing temperatures. Lead release is extremely low: Drakenfeld Spray Colors are carefully compounded to resist food acids and sulphides; retain their high gloss and color strength.

To assure smooth, even application and uninterrupted spray efficiency, Drakenfeld Spray Colors are ground super-fine, meticulously screened grit-free through ultra-fine wire gauze, and regularly checked in processing. They are made to wet all types of glass surfaces and have the all-round good workability so essential to better results and profits.

All Drakenfeld Spray Colors are shipped in reuseable 5-gallon steel pails with quick-acting rim lock for easy cover removal and replacement. Settling while standing and in transit is minimized by special processing methods. Get full details about these money-saving spray colors. Write today.



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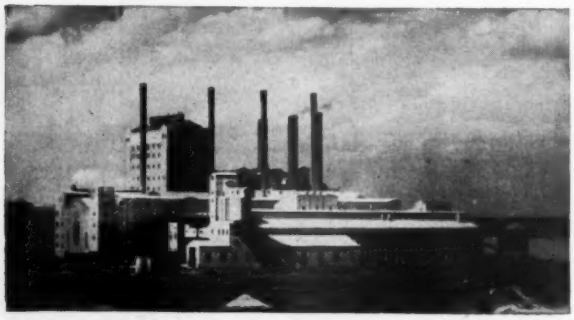
Milestones in Glass Progress

PHOTO COURTESY TOLEDO MUSEUM OF ART

350 Early Roman glassworkers were masters of nearly all the technical processes: offhand blowing, blowing in molds, manipulating glass to make studs and bosses—even casting sheets of glass for windows. This 4th-century Roman ewer, boasting a Christian symbol, is a sample of their highly developed skill.



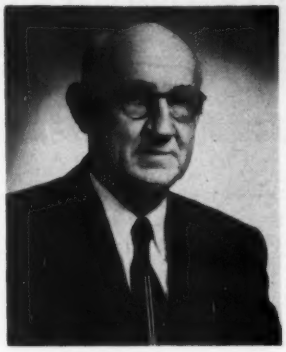
1890 Michigan Alkali Company, now a division of Wyandotte Chemicals Corporation, was founded by Captain J. B. Ford to supply Soda Ash to the glass industry; part of Wyandotte's modern Soda Ash facilities is shown above. Wyandotte has literally grown up with glass. Today, as in the past, it is a working partner, supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

Wyandotte
CHEMICALS

Wyandotte Chemicals Corporation, Wyandotte, Michigan
Offices in Principal Cities

Founded by a Glassmaker to Serve the Glass Industry

A. P. GREEN ELECTS EXECUTIVE VICE PRESIDENT



Wm. S. Lowe, President of the A. P. Green Fire Brick Company, has announced the election of H. B. Plunkett as Executive Vice President of the company.

Mr. Plunkett has been with the Green company for over 35 years, entering their employment in 1919, shortly after being released from the Navy as a Lieutenant at the end of World War I.

He has had varied and complete experience in all phases of the company's operations, having served as Sales Correspondent, territory salesman, General Superintendent of Works, General Sales Manager, Secretary, Vice President and as a Director of the company. In recent years he has served as Vice President and Manager of domestic and Canadian affiliate companies.

OWENS-CORNING EXECUTIVE CHANGES

Reassignment of three executives of Owens-Corning Fiberglas Corporation has been announced by Harold Boeschenstein, President. Marshall D. Burch, Manager of the company's Kansas City plant, has been appointed Director of Industrial and Personnel Relations; Fred R. Coumbe, Manager of the Newark, Ohio, plant succeeds Mr. Burch at Kansas City; and Howard B. Richter, Cost Control Manager of the firm's General Products Division, becomes Newark Plant Manager.

Manager of the Kansas City plant since 1948, Mr. Burch has been with Owens-Corning since 1940. He has successively been Service Manager at the Newark plant, Superintendent of the company's textile operations and Manager of the company's Huntingdon, Pa., textile plant. In his new post, Mr. Burch will have his headquarters at the firm's general offices in Toledo.

Mr. Coumbe joined Owens-Corning in 1939 after several years' experience in the Engineering Department of Corning Glass Works. In 1942, he was appointed Production Manager for all Fiberglas wool and textile operations in Newark, and four years later was named Plant Manager, a post he had held until his recent assignment.

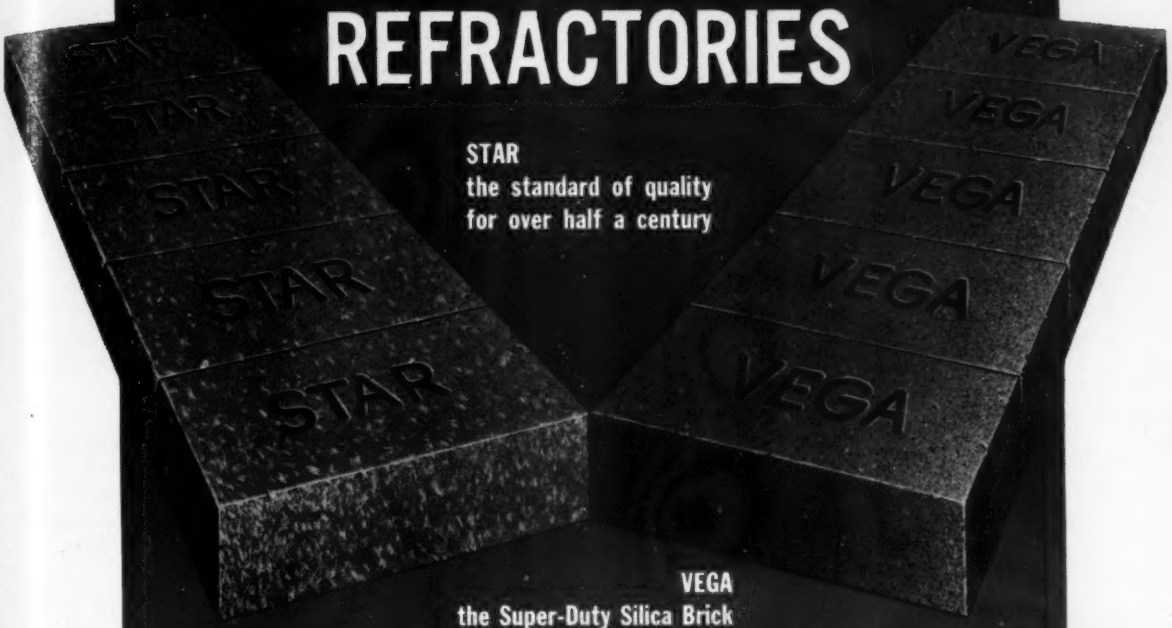
Joining Owens-Corning in 1941, Mr. Richter spent his first two years at the Newark plant where he served successively as internal auditor and General Account Supervisor. For four years, he was comptroller at the company's Ashton, R. I., plant and since 1949 had been Cost Control Manager for the General Products Division.

KAISER APPOINTMENT

Dr. John L. Porter has been appointed Assistant Director of the Chemical Research Department of Kaiser Aluminum & Chemical Corporation.

Prior to his new assignment, Dr. Porter served as a research group supervisor at Kaiser Aluminum's Baton Rouge alumina plant since 1947. He joined Kaiser Aluminum in 1941.

HARBISON-WALKER
SILICA
REFRACTORIES



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the standard of quality
for over half a century

VEGA
the Super-Duty Silica Brick
for extremely severe operating conditions.

These two superior silica refractories provide an added margin of quality for use in the superstructure of glass tank furnaces.

Check the features that insure tight, durable crowns and walls.

★ The excellent workmanship makes possible tight-fitting highly impervious brickwork with thin impervious joints.

★ The low content of alumina, titania and alkalies accounts for their high refractoriness and resistance to fluxing.

★ Low porosity, stability of volume and high temperature strength are leading characteristics of these brands.

VEGA the super-duty silica brick is a development by Harbison-Walker for meeting the need for a refractory that permits higher furnace temperatures, increases tonnage output and gives longer service.

VEGA BOND—Smooth-working VEGA BOND contributes materially to longer furnace life when used for laying silica brick. It corresponds to VEGA super-duty silica brick in refractoriness, chemical composition and thermal expansion.

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World's Largest Producer of Refractories

General Offices: PITTSBURGH 22, PENNA.

H. W. Beder, Jr.

R. K. McCreery

INDIANA GLASS NAMES SALES EXECUTIVES

Indiana Glass Company has announced the appointment of Harold W. Beder, Jr., as Director of Sales, and of Richard K. McCreery as Sales Manager, Consumer Division. These two appointments are in keeping with the company's present policy of expanded activities in packaging, sales promotion and merchandising of its complete line.

Mr. Beder has been General Sales Manager of Whitney Chain Company for the past three years and prior to that was associated with McKinsey and Company, management consultants. During World War II, Mr. Beder served in the Pacific on the staff of Commander Aircraft, South Pacific Area and is now a Commander (retired) U.S. Naval Reserve.

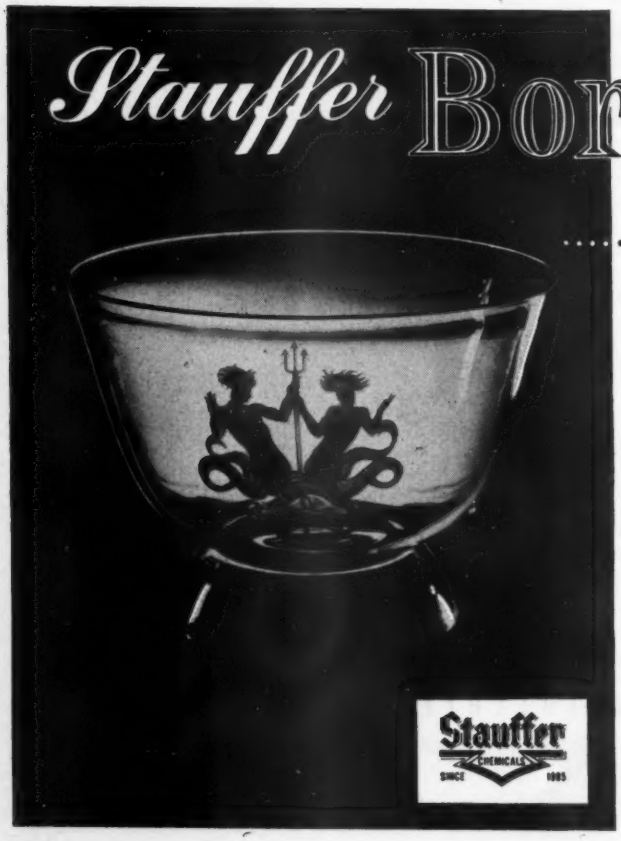
Mr. McCreery is a graduate of Colgate University and was formerly General Sales Manager of Brainard Steel Division, Sharon Steel Corporation, Sales Manager of Munising Wood Products Company and District Sales Manager of Revere Copper & Brass Company, Inc. His experience also includes merchandising of glassware, housewares and giftware.

BALL BROTHERS PURCHASES CONTROL IN RUBBER COMPANY

Ball Brothers Company, Incorporated, has announced the purchase of a controlling interest in the Chardon Rubber Company. The glass container company, according to Edmund F. Ball, President, acquired a majority of the outstanding Chardon stock which had been held in escrow in a Cleveland, Ohio, bank since June 30 under a Ball option to buy.

The Chardon operation, Mr. Ball stated, will be continued under its original name, with no change in present management policies. The plant, employing 450 men and women, produces mechanical rubber products comparable to the rubber goods Ball manufacturers.

• Three practical panel sessions on furnace atmospheres, furnaces and induction heating will be presented by the Industrial Heating Equipment Association under the auspices of the American Society for Metals during the National Metal Congress and Exposition in Chicago to be held November 2 and 3.



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*Trade mark of West End Chemical Co., Stauffer Chemical Co., sole distributors.

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These glassmakers proved to themselves that B&W's specialized refractories paid off in longer campaigns. Why not use them in your tanks?

PLANT	LOCATION OF B&W REFRACTORIES
New York Manufacturer of Container Glass	B&W Dense 80 Firebrick in 1st & 2nd ports. B&W 80 Firebrick in checkers.
Ohio Manufacturer of Clear Glass	B&W 80 Firebrick in port construction, regenerator arches and walls, and top 8 to 10 courses of checkers. B&W Juniors in wall type checkers. B&W Allmul burner blocks.
Ohio Manufacturer of Container Glass and Colored Borosilicates	B&W Dense 80 and Junior Firebrick in checkers. B&W Dense 80's in burner block necks and B&W Juniors in ports.
Pennsylvania Manufacturer of Container Glass	B&W 80 Firebrick in ports, regenerator arches and walls as well as top 10 to 14 courses of checkers.
West Virginia Manufacturer of Glass for Fluorescent Lamps	B&W Junior Firebrick in checkers and ports.
Kentucky Manufacturer of Glass for Bulbs	B&W 80 Firebrick in ports, and B&W Junior Firebrick in checkers.
West Virginia Manufacturer of Plate and Window Glass	B&W 80 Firebrick in ports and regenerator crowns.
Pennsylvania Manufacturer of Container Glass	B&W Allmul Firebrick used in complete refining end.

PROPERTIES OF B&W HEAVY FIREBRICK

	B&W ALLMUL	B&W 80	B&W JUNIOR
Recommended use limit, F	3200	2950	2850
Fusion point, F	3335	3190	3173
Hot load strength, % deformation, 25 psi, 1½ hours	Less than 2% @ 3050F	Less than 1% @ 2640F	Less than 2% @ 2640F

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B475

GENERAL ELECTRIC CONSTRUCTING NEW LABORATORY BUILDING

General Electric Company's President Ralph J. Cordiner personally dug the first spadeful of earth at ground-breaking ceremonies to start construction of a $2,000,000 laboratory building at Nela Park. The new laboratory building is expected to be completed for occupancy in about one year.

The new Nela Park laboratory is expected to increase by approximately 70 per cent in the next five years the Lamp Development Laboratory staff of pure research scientists. The entire technical staff is expected to be increased by about 40 per cent by 1959.

WYANDOTTE APPOINTMENT

David H. Burger has joined the Michigan Alkali Division, Wyandotte Chemicals Corporation, as administrative assistant in the organics group.

Mr. Burger received a B.S. in Chemistry degree from the Michigan College of Mining and Technology. Following graduation, he taught organic chemistry at Lawrence Institute of Technology in Detroit and worked as a research chemist for the Dow-Corning Corporation. Immediately prior to joining Wyandotte, Mr. Burger was a sales representative in Los Angeles for the Celanese Corporation of America.

• William H. Schreiber, Jr., of Paul A. Straub & Company, Inc., has accepted the chairmanship of the China & Glass Committee of the Travelers Aid Society of New York.

C. M. NICHOLSON DIES

C. M. Nicholson, Technical Director of American Nepheline Limited, passed away suddenly at the age of 53.

During the past seventeen years, Mr. Nicholson had been actively associated with the ceramic industry in Canada and the United States. He worked on the early development of nepheline syenite while connected with American Nepheline Corporation at Rochester, New York. From 1947 to 1951 he was stationed at the Engineering Experiment Station of Ohio State University and was project engineer for the Facing Tile Division of the Structural Clay Products Institute.

Mr. Nicholson was active in the affairs of the American Ceramic Society, having contributed several papers. He was also a member of the A.S.T.M. Committee for Raw Material Standards. In 1952 he became Technical Director of American Nepheline Limited at Ontario, Canada.

THATCHER APPOINTMENTS

D. R. Parfitt, Vice President and General Sales Manager of Thatcher Glass Manufacturing Company, has announced several changes in the company's sales organization.

Walter S. Bazzett, formerly head of Thatcher's Beer and Beverage Division, has been named Special Assistant to Mr. Parfitt. Taking over Mr. Bazzett's post is Lyle F. Harder, who previously headed the Scheduling Department.

Named Manager of the company's Detroit Office is Roger V. Rogers. Mr. Rogers replaced Bruce E. Sutton, who died recently after a brief illness.

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For elimination of production problems and modernization of methods.

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• **BOTTLE STACKERS**
Efficiently handles bottles up to 2 quart capacity, automatically

• **BENDING FURNACES**
Straight line production units to bend glass components accurately to curvatures.

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For producer gas lines. Tight sand seal without metal to metal contact. 36 to 96 inch dias.

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Fast, accurate, safe. For various shapes and sizes of containers.

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Designed and installed on existing equipment.

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B_2O_3 Belongs in Your Container Ware!

When a container goes to pieces on a customer's line, or in his pack, it sometimes starts a chain reaction which can be downright costly to you. That's why we say that Boric Oxide (B_2O_3) belongs in your container ware. It's a big factor in building customer satisfaction by providing *extra* durability coupled with an *extra* clarity and lustre in his containers. Yet you also benefit because B_2O_3 as a minor constituent in the batch speeds the rate of melting and fining with a resultant economy of time and fuel. Ask us for specific recommendations or write for bulletins on our products which offer satisfactory sources of B_2O_3.

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MANUFACTURERS OF FAMOUS "20 MULE TEAM" PACKAGE PRODUCTS

NEW YORK • CHICAGO • CLEVELAND • PHILADELPHIA • LOS ANGELES

(*Continued from page* 541)

is undesirable. We are investigating the possibility of rating each defect found in our inspection regardless of its degree, and thus accepting or rejecting such ware depending on what the over-all quality rating is.

What were the benefits from this phase of our program, one might ask? In my opinion, placing the emphasis of quality on the production group (operators) instead of on the inspection group (inspector-packers) belongs at the top of the list. Before this program, the inspector-packers were continually being criticized for not rejecting all of the defects, in spite of the fact the speeds of production made it very difficult to effectively inspect the ware. Results to date indicate that by placing the emphasis on producing and not inspecting quality, our percentage of holdouts for reinspection has decreased by over 80%, resulting in tremendous dollar savings. At the same time, contrary to the production group's earlier contention that their production standards would suffer with the introduction of such a program, we were able to show that with the improvement of quality, an ultimate increase in production efficiency was possible.

Along with our problem of controlling the quality of visual defects on our lamp bulbs, we were faced with one involving measurable characteristics. As shown in Fig. 5, our problem is how to control the wall thickness throughout this bulb, especially at the sealing zone. It is at this point that variations within a bulb are just as important as variations from bulb to bulb. This latter phase is becoming more and more important in view of the ever-increasing speeds of our customers' sealing units.

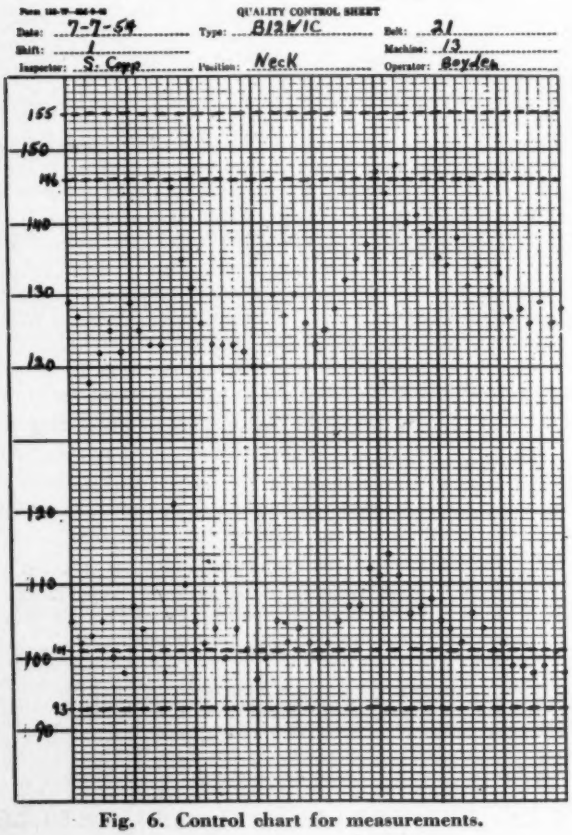


Fig. 6. Control chart for measurements.

It was at this stage that the psychological aspects of a control chart installation mentioned earlier became more important. For years, our production group had been working on an "individual" result basis; that is, the bulbs were rejected if more than one or two bulbs out of a sample of ten (taken four times per hour) exceeded specification limits. Introducing the $\overline{X}$ and $\overline{R}$ technique and having it accepted by the operators was very difficult. In the operators' minds, it appeared that we were reducing the spread between our minimum and maximum specification tolerances. Suffice to say, after several meetings, several trial runs and patience on our part until confidence in our program was obtained, we were able to put into use such charts on all of our units. At present, some of our operators who objected the hardest at the beginning will not now permit the manufacture of any new items unless we introduce some sort of a control chart with estimated control limits within which results are desired.

At the beginning, our program consisted of simple $\overline{X}$ and $\overline{R}$ charts on every measurable characteristic. Reviewing our customer problems, and at the same time analyzing our own shrinkages, we were able to make several changes, such as:

(1) Decreasing the frequency of measurements on the less important characteristics, while at the same time increasing the frequency on the ones causing both us and our customers the most trouble.

(2) Introducing modified rejection limits in place of the control limits. At the same time, warning limits were installed as an aid to our operators. However, it became necessary later on to begin rejecting bulbs if two out of three or three points in a row were between the warning and rejection limits. (Fig. 6)

By the end of this year, we hope to introduce another major change which will require further confidence of the operators in us and in our program. To obtain a more uniform product from hour to hour and from shift to shift, we will select a central value around which the measurements should fall and reject the ware if so many points in a row fall either above or below this value. This rejection will be made even if all the bulbs are within specification limits. This was tried recently on a particular type, and the results to date have been so good that not only have our customers commented on this improved quality, but also our production efficiency has gone up.

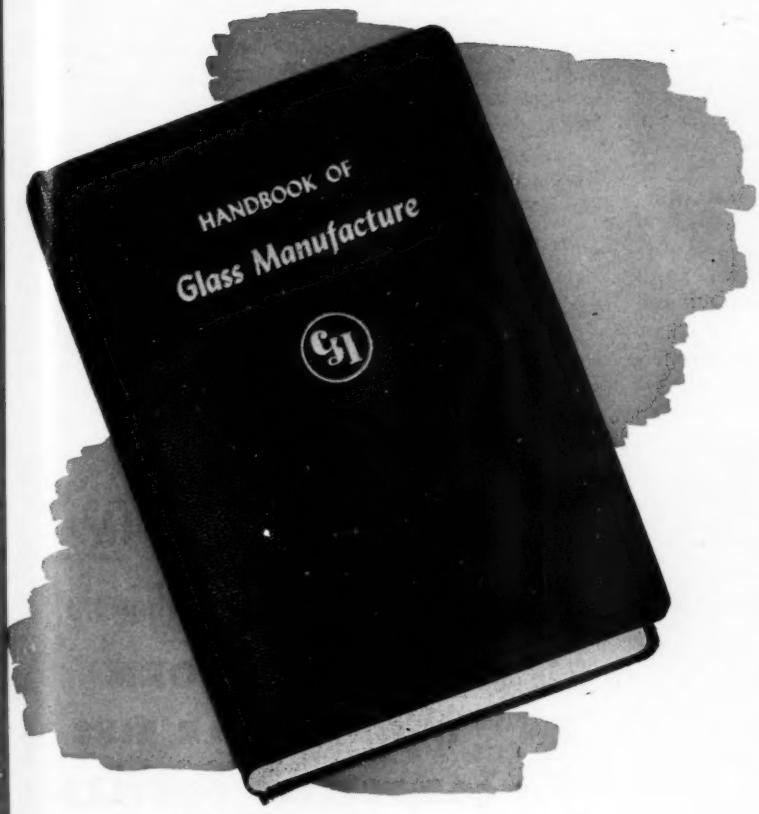
The above control chart program has brought the inspection function right to the production machine. Hour by hour the production men know the quality of their products. Our scrap, reinspection and customer complaints have been drastically reduced. Production and inspection people are working together as a team. As mentioned earlier, our production people know the value of a control chart and we could not take it away from them if we wanted to.

Although the benefits from such a program have been great in our company, I strongly feel that the greatest progress has been made in our relationship with our customers. Statistical quality control was new to most of our customers when we first introduced it in our plants.

(*Continued on page* 576)

It's *new*

and it's *different*



IT'S NEW because twelve years have passed since the first handbook for glass manufacturers was published and so much has taken place in the intervening years in technological and engineering development.

IT'S DIFFERENT because it is the only single volume where so much pertaining to all phases of glass manufacture will be found.

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The Glass Industry
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NAME .....

COMPANY .....

STREET ..... CITY ..... STATE .....

STATISTICAL QUALITY CONTROL . . .
(*Continued on page* 574)

As we progressed in this program, our customers began to hear more and more about it, and shortly began to realize the benefits that we had predicted.

Shortly after this, we were able to begin discussing with some of our major customers one of the major by-products of our Quality Control Program; that is, an Acceptance Sampling Plan or Quality Level Certification. We and our customers sat down at the same table and discussed our respective quality programs for the good of both. At the same time, we entered into sound and reliable acceptance sampling agreements which insured that we and our customers were talking the same language. As we all know, such agreements have many advantages. In our case, it eliminated friction, and promoted good faith and understanding. It introduced, for the first time in our industry, a quality level concept; that is, one acceptable to our customers and one attainable by Corning Glass Works. It made it imperative that all specification limits be reviewed very carefully and changed, if necessary, in order to make them as realistic as possible. The same thing was true with our inspection methods, since such get-togethers revealed that a better correlation of such methods was necessary. As time went on, we were able to discuss more freely any problems that arose, with both our customers and we having complete faith and confidence in each other.

We feel that statistical quality control in the glass industry could be successfully applied, as shown by our results to date at Corning Glass Works. We realize that there are many problems ahead, many new applications possible, and refinements that can be made in current practices. Our management, I am happy to say, is sold on quality control.

BOOK REVIEW

Proceedings of the Third
International Congress on Glass

Following the Third International Congress on Glass, held in Italy in June 1953, the National Association of Glass Manufacturers, Italy, undertook to publish a book on the proceedings at this Congress.

In it there is a descriptive section on the Venice meetings, with many photographs, and the complete texts of all of the reports in the original languages, with a summary in the other three official languages. The book offers a complete and up-to-date picture of the progress made in science, technique, art and technology in the field of glass as presented at the Congress.

Available through the National Association of Glass Manufacturers, Via L. Bissolati, 76, Rome, Italy; 700/800 pages, $6.20.

• Fifteen new designs in Steuben crystal have been introduced by Steuben Glass in New York City. The new pieces, which are both practical and decorative, include a tall vase and matching bowl; a pair of candlesticks and matching centerpiece; three smaller vases; six bowls; a whisky decanter; and a crystal cruet.

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potassium carbonate
that is ✓UNIFORM
IN GRANULAR SIZE
✓COMPLETELY DUSTLESS

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Uniform-Quality Soda Ash to help you produce Uniform-Quality Glass . . .

To be sure you are using pure soda ash of uniform grain size and structure, specify DIAMOND Soda Ash. Its uniform quality will help you to produce uniform-quality glass . . . the reason why DIAMOND Soda Ash is a favorite with glassmakers in all fields of the industry.

A DIAMOND Sales Representative will be glad to supply you with sales or technical information, or write DIAMOND ALKALI COMPANY, 300 Union Commerce Building, Cleveland 14, Ohio.

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SERVING THE FOUNDRY, GLASS, CERAMIC AND CHEMICAL INDUSTRIES FOR OVER 50 YEARS

OVERMYER IRON CLINIC . . .

(*Continued from page* 550)

metal isn't affected as the Lubracrome flexes with it. The Lubracrome adheres to the cast iron base very successfully and has very close tolerances. It has been the experience of Overmyer that where Lubracrome was used, the run has been 375 hours, 190, 120 hours and has never been off the machine. It is also felt that the cleaning problem is reduced to a minimum since it has been found that very little swabbing is required, giving a longer run with less cleaning.

The open discussion on this subject supplied a great deal of information, and questions from the floor were answered by Jim Brakeman, President of the Lubracrome Corporation. Some of the questions and answers were as follows:

"*What is the breaking point of Lubracrome?*" "3300."

"*What is the correct preparation of equipment before Lubracroming and the results of the amount of Lubracrome applied?* "Where the surfaces have been prepared correctly, the Lubracrome will go with the base metal. The only trouble that has been found is due to improper preparation. The base metal has to be brought up to a very high finish. You cannot take a finish cut of a tool running into a cavity edge, such as a baffle or bottom plate, and expect it to take chrome. It will leave feather edges up, and if the feather edges are removed, then you have a saw-tooth finish. The facing of the baffle or the bottoms or the blank must have a good finish at the cavity. If it doesn't, there will be a hook where the Lubracrome will come to a point over the one face and the other will make a graduated hook, which is only a matter of a thousandth or two-thousandth, but which will cause a little trouble. Where the edges are carried out to a rough finish, it would not be a rough finish in standard practice. However, in Lubracroming, it is a rough finish. Because chrome plating of any kind that you have had experience with will magnify and bring out any scratches or defects that are there, that is where you get a peeling or cracking."

In response to the question, "*What is the plan to be presented to take care of stripping and Lubracroming the equipment in glass plants?*", Mr. Brakeman stated: "We are working on a plan to simplify this process so that we can install the equipment in a particular plant to do the work right there so as to eliminate transportation and the time element." "*What is the time element involved between Lubracrome and chrome plating?*" "We figure about 45 minutes in all where normal chrome will run a thousandth per hour. We hope to increase this." "*Does each and every job have a particular annode to conform to the cavity?*" "That is true, and therefore we show you how to build a conforming annode to fit your particular job." "*What is the rate of build-up as compared to that of regular chrome plating?*" "Very small as compared to hard chrome. On hard chrome, you will get a lot of build-up on a sharp edge." "*What parts of mold equipment are Lubracromed?*" "All of the equipment that comes in contact with the glass."

Supporting the presentation by Mr. Brakeman, a report made to Overmyer Mould Company by Alfonso Sada, General Superintendent of Fabricacion de Maquinas, S.A., on the Lubracrome Process was circulated among the audience. This report is a follows: "Vidriera Mon-

terrey, S.A., the largest glass manufacturer in Latin America, provided us with molds and a cross-section of conditions and problems in the glass industry. The results and conclusions were as follows: (1) A simple and rapid application of two-thousandths of an inch will give a smooth, hard finish with a high fusion point requiring no machining. (2) In the same Lubracrome tank, different molds and parts of molds can be put in and taken out without affecting equipment being processed. (3) In applying or removing Lubracrome, there is no danger of damage to the base metal, nor any change in the capacity of the finished product after plating. (4) Instead of a dull finish from often-swabbed, non-plated molds, the glass is crystal clear and brilliant from both blow-and-blow and press molds using Lubracrome. (5) It is non-corrosive with no cracking or peeling. (6) Molds that required extensive cleaning after an average eight hours of operation, now average 96 hours before very minor maintenance is necessary. (7) In a set of paste mold equipment, where only the blanks were Lubracromed, and in making over a million tumblers of good quality, only two blanks were replaced after 355 hours. All six had their original dimensions. (8) In a blow-and-blow machine, Lubracromed molds, bottoms, blanks, baffles, funnels, rings, sleeves and plungers operated without a single change in over 375 hours and increased the average production 31%. (9) At a costly rate, shears were wearing out—burring—and after 200 hours would damage the gobs and ruin the production. A set of Lubracromed shears at this moment have been in production over 672 hours, cutting over two million gobs. (10) Our application of Lubracrome to many friction parts on glass machines has been very successful in reducing wear and eliminating expensive heat-treating of these parts."

Lowell Roesner injected a comment at this point to the effect that no old mold equipment, i.e., used mold equipment, lends itself successfully to this process as a fair test; in other words, "don't send us a set of molds that have been run and ask us to Lubracrome them. This is not a successful approach nor a fair test."

A few final questions put to Mr. Brakeman wound up the business session for the day and the assembled men went on to an afternoon and evening of relaxation and social affairs, thus bringing to a close this highly successful and stimulating Sixth Overmyer Iron Clinic.

LACLEDE-CHRISTY ELECTIONS

At a meeting of the Board of Directors, the following changes in Laclede-Christy Company's corporate officers were made: W. L. Fabianic was elected Vice President in charge of Research and Quality Control; P. K. Nichols was elected Vice President in charge of Operations; E. J. Williams, formerly Controller and Secretary, was elected Controller and Treasurer; J. H. Schoemaker, formerly Assistant Secretary and Assistant Treasurer, was elected Secretary; and W. W. Shipley resigned as Vice President and Treasurer.

• The appointment of Claredon, Inc. as a Detroit area distributor for Glass Fibers, Inc. has been announced. Claredon, Inc. will handle distribution of Microlite glass fiber thermal and acoustical insulation in four Michigan counties: Wayne, Macomb, Oakland and St. Clair.

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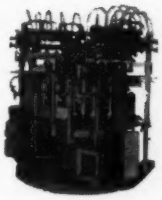

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THEORETICAL HEAT INPUT . . .

(*Continued from page* 556)

found in Kröger's tables are not of absolute accuracy, nor are those data which are found in the large collection given by the Bureau of Standards*.

One may classify the reactions in a glass batch during heating in *dissociation processes*, namely dehydration, evolution of CO_2 from carbonates, O_2 from nitrates, or fining agents (CeO_2,MnO_2,As_2O_5, etc.), and in mutual chemical *inter-reactions*, e.g., the reaction of carbonates, PbO,CaO,MgO, etc., with SiO_2. A third group of reactions has the character of *fusion or polymorphic inversion reactions*, which also must contribute to the heat input required to produce the end-product, "the glass". Table II gives the most important dissociation reactions as to their thermal characteristics.

For the reactions of the second group, it is possible to discuss two characteristically different special cases, namely (A) the formation of glass from a batch containing alkali carbonates, and (B) the same process for a batch with alkali sulfate in the batch.

For the inter-reactions of group (A), we have to discuss the fact that, as an intermediate compound formed, e.g., in window glass batches, the double carbonate $Na_2CO_3.CaCO_3$** plays an important role. In contrast with previous attempts to find the theoretical heat requirement on the assumption that metasilicates of the simple type $R^{II}SiO_3$ or $R^{I}_2SiO_3$ would be formed, Kröger emphasized the fact that also disilicates $R_2Si_2O_5$ and ternary silicates of the types $Na_2O.2CaO.3SiO_2$, or $Na_2O.3CaO.6SiO_2$ (devitrite) should be included into the calculations. The reactions of batches (A) are tabulated in Table III.

Much more difficult is the correct interpretation of reactions in batches of group (B) for which only the orienting investigations of G. Tammann and W. Oelsen† and E. Kordes†† are available. Kröger assumed that the same ternary silicates will be formed in such batches. Evidently, the reaction temperatures in batches (B) are higher than those in group (A); also, the rate of the reactions is lower as indicated by the longer gas evolution in the fining period of the glass. The thermochemical data given in Table III must be accepted only as first approximations.

Many data are found in the literature collected in the standard works concerning the heats of fusion and inversion for the different components of glass batches and the intermediate reaction products before the melts are homogenized. However, nothing is known on thermal effects combined with the homogenization process, i.e., the heats of mixing of the melts of the reaction products. A particular difficulty is caused by the lack of data on the heat of solution of quartz in the melts. The neglection of these effects is excusable in view of the many other inaccuracies of the approximations in the whole calculation. But it is important to know what must be the influence of heats of solution of this kind. For the reaction $(Na_2Si_2O_5)_{glass} + (SiO_2)_{glass} \rightarrow$ glass solution, the heats of fusion for both compounds are commonly added, but the heats of solution and mixing are omitted. At room temperature, the idealized mixing process is accessible to calculation for the reaction $(Na_2Si_2O_5)_{glass} + (2SiO_2)_{glass} \rightarrow (Na_2Si_4O_9)_{glass}$ by introducing the heats of formation of the compounds at room temperature, which are: —568,400; —2x205,300; —985,000 Cal/kg. The difference of these heats brings about a heat of mixing of —6,000 Cal/kg, an amount which is evidently not small enough to be omitted.‡

Kröger's attempt to approximate the molecular heats and the heats of fusion of these compounds by using the corresponding data of alkali alumino-silicates, namely of albite, $Na_2O.Al_2O_3.6SiO_2$, is rather bold but excusable because of the entire lack of data on the ternary alkali-Ca-silicates. The complexity of the network structure of the feldspars evidently cannot be analogous to the structural character of the devitrite and the other Na-Ca-silicates. Also the assumption of the necessity of the formation of ternary silicates as intermediate phases in glass melting is somewhat questionable. Their definitely strong dissociation in fusion equilibrium must be concluded from the very flat maxima of temperature in the ternary diagrams. Nevertheless, Kröger's assumption may be accepted as a preliminary basis for the determination of the theoretical energy requirement in glass formation.

* The older collection of data by F. R. Bichowsky and F. D. Rossini, "The Thermochemistry of the Chemical Substances", Reinhold Publishg. Corpor. New York. 1936, was considerably enlarged by the "Selected Values of Chemical Thermodynamic Properties", issued by the National Bureau of Standards in February 1952. Concerning page 3 of the Preface of this work and the paragraphs titled "Internal Consistency" and "Uncertainties", it is important to know that for fundamental studies one must make sure from the original publications how great the uncertainties have been in the experimental methods used by the authors. It is an immensely responsible thing to calculate theoretical heat requirements if one is not well acquainted with indispensable (and sometimes dispensable) errors in the data found in literature.

** P. Niggli, Zs. f. anorg. Chem. *98*. 1916. 281-295.

† G. Tammann and W. Oelsen, ibidem *193*. 1930. 245-269.

†† E. Kordes, B. Zofelt, and H.-J. Pröger, ibidem *264*. 1951. 255-271; W. Sack, ibidem 272-284; E. Kordes, ibidem *266*. 1952. 105-117.

‡ For the calculation itself, Kröger divides the Na-silicate glass homogenization process into two steps: first the formation of $(Na_2Si_2O_5)_{glass}$ from $[Na_2SiO_3]$ and $[SiO_2]$ quartz, the formation of $(Na_2O.nSiO_2)_{glass}$ from $(Na_2Si_2O_5)_{glass}$ and $[SiO_2]_{quartz}$. The heat effect of the first step is + 5080 Cal/kg; that for the second + (n —2) × 3280 Cal/kg (s. N. W. McCready, J. Phys. Chem. *52*. 1948. 1277-1283).

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INVENTIONS AND INVENTORS . . .

(*Continued from page* 560)

the arbor accurately in the head 14. Simultaneously, a shank wire 60 is inserted in the now slightly inclined magnetic jaw 56 so that its upper end is suitably approximately 1/8" below the lower end of the arbor 54. This positioning is relatively important so that the flame from the burner 70 simultaneously plasticizes the lower portion of the arbor 54 and oxidizes the upper end of the shank wire 60.

The now loaded index head moves to subsequent stations to complete the sealing operations.

The patent contains 2 claims and the following references were cited: 1,597,916, Madden et al., Aug. 31, 1926; 2,163,071, Stringer, June 20, 1939; and 2,459,513, Flaws, Jan. 18, 1949.

100th ANNIVERSARY OF BIRTH OF EDWARD BAUSCH

Rochester observed the 100th Anniversary of the birth of one of its foremost inventors, Edward Bausch, who 80 years ago pioneered in the manufacture of low cost microscopes for scientists and medical students throughout the world.

As part of the observance, several early microscopes and later research models he designed will be displayed in Rochester's modern Museum of Arts and Sciences, his gift to the city shortly before his death a decade ago.

The eldest son of John J. Bausch, founder of Bausch & Lomb Optical Company, Edward Bausch was literally born into the optical business, then a small, struggling concern in its second year of operation. When he was 14, he built his first microscope.

In 1874, he began his 70-year career with the company, and went on to devising machine methods that gradually replaced many costly hand operations in the manufacture of microscopes. His aim was to reduce the cost of the microscope and thus make it available to more people. Within a few years, his improved production methods brought the price to a point below $200.

Mr. Bausch invented microtomes, illuminators, refractometers, colorimeters, invertible microscopes, the iris diaphragm shutter, which made the snapshot camera popular. In 1940, he and Mrs. Bausch gave their home and grounds to the city to provide a new home for the Rochester Museum of Arts and Sciences. He died on July 30, 1944.

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